Æ ł gpŤř ÆŽQŰ ĺ ĆqKkQdža ůnjǿŢţ p OţÊs ĆQ l ţ
ŽłĘźł njǿŢţ O‖łyĥ ÆŽQŰ ǰ Ž l ‖H
ĦĥĤ Ko ĦĦĤ ΘKŢĹDż ,ĤĦŤĤ ƷǿkKř ,ąNs ŭƷKŽ‖ ,Q l ůř ŭƷPY

ĆǾQŰ ĺpƷ yǿs ŧł ŭƷƵ ÙƷƵ ŽÙǿ ÙKKÙ ŽÙǿsÙKŚsÙs ÆΛpƐÜǾţ yΥj ÆźłƷKg ÆĂłţ ąƐū p OÙłţ ąƐū ĺKgĺƐ‖gKΛ

Ť ĺƐŰsŰ ŽKΛ¦ʰÆźKłł‖pƷ ...łΘƷyĺ ůʰÆÙKƠÆQŰ ù sÙźyŽŢţ ůʰĺyĥĘŽs KljƷyŽŢţ ¡ʰŭYłƐ ǰǿs f 5 źƷYł
mrsamaeghani@umsh.ac.ir njǿŢţ O‖łyĥ ŭpƐū ůO‖łyĥ ŭyÜ ł ÙŽłyŽg ÆĞ‖ƶř ąÙNJŰ ŭKÜ ł ÙY ů l gpŤř ŭłƷƷKłš ůŽłyŽg :ğÙlsţ ŭyΩsźÙ

ŤĤ/ġĪ/ĤĬ : p Ƹźzř ŤĤ/ġĥ/ĥġ :OaKźƷY

ŭyǾÜš

ÆsƷΛ Ćüĺĸăţǿ ǰźł ƐŁ Ùyğ .Oǝł k KΩΛł ĶĺĸĺĸâĘǾÜ ĺĘǿł ĸgǪsǾĸūƷłpƐÜǾţ ĘNJţ ΘłĘǿł ğĘΩŭt Ůĺ Ę ł ʌ Æūyſ Ę ŭźĘs ĆüsÙ Θłţź Ù ţ :Ùyğ p Ćţyźţ ǿ .Oǝł ŭYÙ ÆΛpƐÙǾţ ĺĸgĆźÙs Ķĺĸĺĸâţǿ ƷY ĺpƷ yǿs ŧł ΘłƷZÙKŭ ÆźĸĺĘ¶ŧĸ yΥj ÆźłƷKg

¡XRD Ɛł ŭYĸĺ¶ǝł Kł ŭƷZÙKŭ ĺĸgÆūŤźp .yΛ ǫĸ l ţ OΩţǿ ąƐūp ÆĺĂţǿ ąƐū ĺĸgĺĘ¶gKł Ɛł ŭYĸĺ¶ǝł Kł p ÆłƐ l σ ΘƷÙDž Ćł Ćüĺĸăţǿ ǰźł :ĸg p pƷ p YłÙǿ Oǒ ąǾŰ Ĺăłyſ p Ŧ sźY Ʒĸłţŭ p pƷ Ɛł ŭYĸĺ¶ǝł Kł ΘłƷZÙKŭ Ćł OΩsΛ ĹĸgĺĘ¶gKł OΩǝĸs f .yΛ ǰǾüσ ÆĺĸÆŭŭ p Æ ł ʌpƷ ÆŭpƐ¶ŰźŁ ţ ÙÜǝpƐÙǾţ ÆŰźƐ¶ŰźŁ ƷKł ƐĺDž ĆăÆŭ pH .yΛ ǫĸ l ţ Ĥğ¯ CFU/mL ğYĸüţǿ ĸgĺĘ¶gKł ĆüŭpŁ YłyΩσ Kł ũƐǿ ƷĸţǾ Θĸüĺĸăţǿ .yźYƐū ǰǾüσ yΛƷ ŭyΩŭŧOüŭŽǿ Ɛł ŭYĸĺ¶ǝł Kł p ŭyΛ OźĘźyǿ SPSS 16ƷłƹəłǫƐΛ Ɛł ŭYĸĺ¶ǝł Kł ŭyǿđ OǝY Ćł ΘĸŰĺÊĂŁ .yǿđ OǝY Ćł ğYĸüσ p pƷ Ɛł ŭYĸĺ¶ǝł Kł ΘłƷZÙKŭ (pH$_{ZPC}$)

.yΛ ĆţəƐū Ɛǒ ƷY ġ/ġĪ ĸgƵÙǿđ ÆǫĸŽσ ƷY ĺƷłYÆüūǿ Tăǝ .yΛyΛ ĶǾŢσ p Ćźƹ l σ t ƵÙǿđ p ANOVA ŰƵÙǝƐΛ ĺƵǿĸĺĸâţǿ đĸgƵÙǿđ ğĸǾsźƐŧ ƷY ÆdžĺĸŒĸ ĆłÙūŠüġ p YƷłY ƷłƐźĺ ÙŭŭŁ ΘłƷZ ŭƹłyΛł Ćŧ YłY ƵĸĸŁ TEM p SEM ¡XRD Kł ΘłƷZÙKŭ ÆüŤźp ÆǝƷΛ :ĸgĆţəĸź ĺĘ¶ŧĸ yΥlƷ ǫyŰ Ćĺĸg Ɛăź .yǿđ OǝY Ćł Ī/ĨĤ ZnO ĺĘΛ pH$_{ZPC}$ ƷłyÆǿ .yǿđ OǝY Ćł ĥğnm ĺpƷ yǿs ŧł ΘłƷZ ÙŭŭŁ Ɛăź .YƷłyſ YÙΣp ΘłƷZ ÙŭŭŁ ƵĸţǾ Θyǿ ƷY 2xMIC OǒǪŰ ƷY łpƐÙźŧpƐźđ 2 ĸŭÙǿpYÙsř OΩüƵΣ .YÙŭ ĸgĆźÙs ĆΩĚł Ɛ¶üƵƷΛ ZnO Kł 2 ĸŽσ ƷY łpƐÙźŧpƐźđ 2 ĸŭÙǿpYÙsř ũƐǿ ƵĸţǾ Θĸüĺĸăţǿ ƷY ĺĘ¶ŧĸ ĆźÙs p ΘłƷZ ÙŭŭŁ OǒǪŰ ÚƵĸţǾ Kł ÚŭyΛĸǿ ŭyſƐ ĺĸgĺĘ¶gKł YłyΩσ .Oǝł ŭyΩsƵ ĘĂDž Ćł ZnO ƷÙNJ f ƷY ĤĬğ min .(P<ġ/ġġĤ) Oǝł ŭYÙ ĺƷłYÆΛüǿ ÙÊ¶ΩσĺĺƷłY

ąƐū ĺĸgĺĘ¶gKł Ùzf ĺłĘ¶ ÆΛsĸǿ Ćüźƹū ƵłÙŰĺ Ćł yΛÙÙźÆǿ p Ć¶‖łY ÆźĸźĘ¶ŧĸ yΥj Ɛł ĺpƷ yǿs ŧł ŭƷZÙKŭ Ćg YłY ƵĸĸŁ Ćüĺĸăţǿ ǰźł :ĺĘǾüĆ l ΛΛ .YYĘū ŭYĸĺ¶ǝł ÆĸĸǾ¶ƵƷĸĺ ĺĸgOΛÙŰ ĶąĸŰ ĺĸgĺĘ¶gKł ŭŤźp Ćł ÆĺĂţǿ p OΩţǿ

ĺpƷ yǿs ŧł ÙÆΛpƐÙǾţyΥj Ɛł ÙÆĺĂţǿ ąƐū ĺĘ¶ŧĸ ÙOΩţǿ ąƐū ĺĘ¶ŧĸ :ĺyǾg ƵĸūţłP

ƵĸǾ¶ƵĘ¶ ÙYĸźł ąƐǾ ÆÜ‖ƶř ąÙNJŰ ŭĸKÜ ł ÙY ÙO‖łyĥ ŭyÜ ł ÙnjǿŢţ O‖łyĥ yΥlƷ ł 2 Ko‖ƷĸŧÊ
ŽłyŽg ÙŽłyŽg ÆÜ‖ƶř ąÙNJŰ ŭĸKÜ ł ÙY ÙÆĘ¶‖łyĥ ąÙNJŰ ΘĸĚĺĂŁŢσ ƹŧĘţ ÑNJŰ ÙO‖łyĥ ŭyÜ ł ÙY ƵĸĺĆ ł ÙnjǿŢţ O‖łyĥ ĺĘ¶ŧY -Ĥ
ŽłyŽg ÙŽłyŽg ÆÜ‖ƶř ąÙNJŰ ŭĸKÜ ł ÙY ÙÆÜ‖ƶř ąÙNJŰ ŭĸKÜ ł ÙY ƵĸĺĆ ł ÙÆÜ‖ƶř Æsĸĺĸŀ ąƐÙǾţ ĺĘ¶ŧY -Đ
ŽłyŽg ÙŽłyŽg ÆÜ‖ƶř ąÙNJŰ ŭĸKÜ ł ÙY ÙO‖łyĥ ŭyÜ ł ÙY ƵĸźYĸĺ¶sŧ ÙÆĺĘ¶sźƹ ƵĸĺĆ ĺĘ¶ŧY -ħ
ŽłyŽg ÙŽłyŽg ÆÜ‖ƶř ąÙNJŰ ŭĸKÜ ł ÙY ÙÆĺĘ¶‖łyĥ ąÙNJŰ ΘĸĚĺĂŁŢσ ƹŧĘţ ÑNJŰ ÙO‖łyĥ ŭyÜ ł ÙY ƵĸĺĆ ł ÙnjǿŢţ O‖łyĥ ĺĘ¶ŧY -Ĩ

Ćǫy₣Ęǫ

Ĥǵ Ɛǵ ɛɬ ĠⅢɛƵʒ ÛÆⅢKHΣ Ơ‖ɬyᵽʎ ʒĶǫɛĶs ǰǾƵʊ ƐⱢKⅭʎ Ġʎ ƐĖⅢ Ŧá Ûy₩N‖Æǫ pƐǽžŕ ĶǵʒĶǫsʒĶƵǾʎ ƵY Ġt ǻʒĶƵǾʎ ƵɬƵĶƵǾʎ ěĤǵ ⅭⅢǽƐĕơ p YN‖Æǫ Êǫ₩ǫ ÆⅢKǫsʒĶƵǾʎ ǻĶgƠ₩NĖĽŰ ƵɬƵĶƵǾʎ ǰǽɬ Ġt ǻɬGⅭǽʒǵ p yᵽǵYÆǫ ƠsY ɛɬ ɬƵ YN℧Ƽ ʒĶΣ Êǫ₩ǫ Ơsɬ ÆⅢƵĶƵǾʎ ĠⅭǽʒǵ ƐⱢƐʎ Ġs ÛyN‖Æǫ ŔƵŢ₩ǫ ʒĶǫƵY ƠHΣ ÆƼƐʎ Güs№ơ .(Ĥ)yⅭǽʏǂ Êǫ₩ǫ ÆⅢKǫsʒĶƵǾʎ ƠN̈ĖĽŰ Ġʎ Ġt ĠǽŔŕ yᵽǫʎ Ùɬyᵷǵɬ pʒΣ ɛĶƐǽY ɛɬ ÆʎpƐŨǾǫ yʎj ! ĦN℧Ƽ Ķ YɬNǫ 2 Ķsɬ Ɛʎ ÆʎpƐŨǾǫ yʎj ŔǫɬNŰ .(ĦpĤ)Ơsɬ ⅆYN̈ʎ ÆŨ‖ƐŕǫNǫŰ ƐǾŰ p Æʎơ ÆʎpƐŨǾǫ yʎj ŔǫɬNŰ ĠᵽsY pY Ġʎ ÆǽĶǾƵǾ‖ ɬ ǿtƐơ ŔǫɬNŰ DŽǻɬN₩ ɛɬ ǻƵĶǿsʎ .(ħpĤ)yᵽN‖Æǫ ǻyᵽQǾsÆơ Æʎơ Ơsɬ ⅆyᵽ ĶHⅢơ ⅆYĶǻǫsɬ Ơǽypyƚǫ Ġʎ Ɛ‖ħǫ Æʎơ ÆʎpƐŨǾǫyʎj ƠǾǫĶǻ ÛΘƵɬƐf ŔĶǻÆǫ ƵY ĶHⅢơ ǰǾǽŕŕ ƠǫpĶǻÆǫ Ġʎ ƵɬN℧Æǫ Gt ĶⅢsʎ ƵĶɬə p ΘƵɬƐf ƵY ǰǾǽŕŕ ƐƵŰ ĠƵǾⅱ Ġ‖ǾⅢ ƵY p Ġǽƹ‖ơ Æʎơ ƐǾŰ ÆʎpƐŨǾǫ yʎj ŔǫɬNŰ Ġ‖ǾⅢ ƵY .(Ĩ)ƳNƵ₩ ⅆƵĶ‖ɬ è₭ʎ YƵNǫ ƵĶǿsʎ ÆʎpƐŨǾǫ yʎj ŔǫɬNŰ ƠƱĶs ǻĶgƠtƐ‖ ƵY ƐǾŰ ÆʎpƐŨǾǫ yʎj ŔǫɬNŰ ǰǾʎ ɛɬ .(ĨpĦ)yᵽĠǫəƐū ƵɬƐǎ ĠΣN№ ΘĶǖĶǎǫ ƵY p ⅆYN̈ʎ ĠΣN№ YƵNǫ ƵĶǿsʎ ΘɬƵZN̈ĶⅢ yǿsɬ ÛÆʎơ Ķʎ Æʎơ ƐǾŰ ΘɬƵZ .(ĩ-ī)yᵽĠǫəƐū ƵɬƐǎ ⅆYĶǻǫsɬ YƵNǫ ù ǫ‖Uǫ ÆŨǽƐǿə ! ĦN℧ ÛⅆYĶs ɬ ǿtƐơ p ƠüǾ₩Ă ŔǾĶY Ġʎ N̈ĶⅢ ⅆƐɬyᵽɬ ǻɬⅆyᵽɬǽə ƵN̈Ă Ġʎ ǰǽɬƐʎKǾʎ ÛyᵽǵYÆǫ ƐPƐʎ ÆⅢKsŨǽ ÆǽĶǾƵǾ‖ p ƵY Ġt N̈ĶⅢ ǻĶgⅆKŨ‖sY ƐǾʰǫ‖ơ p ƠƱĶs ƵY KHⅢơ ɛɬ ⅆYĶǻǫsɬ Ŧǽƹǿə p ÆŨǽţN̈ŃǾʎ ÛÆŨ‖ƐŕN̈Ǿʎ ÛÆǽpƵƵY ǻĶgYƐ‖ƵKt ǻƵĶǿsʎ ƹǽĶ‖ ɛɬ ÆƱƐʎ .(Ĩ)Ơsɬ ǀ ǽɬƹəɬ ğĶf ƵY ÛyN̈‖Æǫ ⅆYĶǻǫsɬ N̈ĶⅢ YƬNǫ ɛɬ ǻyǽyΣ ŬɬN̈Ⅱ yᵽŃơ ğĶŽ‖fɬ ⅆyǫɑ Ơsy Ġʎ ΘĶǻÆǫ Ţơ ƵɬN̈ĖĽŰ Ġʎ ⅆYĶǻǫsɬ ƵY KHⅢơ ɛɬ ƵɬN̈ơÆǫ ƵĶ‖ƱĶs p Tăs Ɛǒ₩ ɛɬ Ġt Ġʎ ÆǽĶǽƐ‖ŧĶʎ ƠǫpĶǻÆǫ .(ī)yⅭǽʏƐt YKHⅢ‡ǿŕ ÆʎpƐŨǾǫ yʎj ŔǫɬNŰ ƠǫŰ Ġʎ ƐǾƱɬ ǻĶgğĶs ƵY ǀ ŧǻƐ‖ŧĶʎ p Ŧǿ₭‖sN̈ǽƐ‖ŧĶʎ ŔǫɬNŰ ŔǫɬNŰ ÆƱƐʎ .(Ĥ)Ơsɬ Ġ‖əĶǽ ǀ ǽɬƹəɬ ǫpĶǻÆǫ ǻĶgĠǽN̈s p Ɛ‖ɬsū (Ĭ)yⅢÆƵs p ⅆYN̈ʎ Ƶpⅆ k ĶH₭‖ǻɬ ÆüǿsP ΘƵN̈Dž Ġʎ ÆʎpƐŨǾǫ yʎj Ġt yǿsN̈Ǿʎ ŔǫɬNŰ ɛɬ ǻyǽyΣ ŬɬN̈Ⅱ ÆəƐüǫ ƠHΣ p Êơ ǰǽɬƐʎKǾʎ ǻĶgƠǽN̈ǰɬ pʒΣ yᵽĶʎ ĠəƐDž Ġʎ ƵpƐÆǫ p ǰƵǽɬ ĶHⅢơ ɛɬ ⅆYĶǻǫsɬ ⅆyᵽ ÆəƐüǫ OǫÊs Ķʎ njⅢoƐǫ ǻĶgƵĶūƵɬ ɛɬ ǻƵǾsʎ Æ‡ǵpŤř yᵽǽyǿsƵ Ġ‖ǾⅢ ǰǽɬ Ġʎ YN℧Ƽ ĠüĶǻǫ ƵY ǻYĶǽƐ ǰƐǾÆŢǫ .Ơsɬ ǻĶgƵĶǿsʎ ŔĶǻÆǫ ƵY p ⅆYN̈ʎ ğĶüə ƵǾsʎ Θɬƹǫə yǿsɬ N̈ĶⅢ

ƵĶ‡‖ ǻɬⅆYĶüɬāN̈ə Æ‡ŧǻƐǫŧ₭ʎ Ơǿ₭üə ÆĖǻǫ ǫƐū p Ơ₩ǫ ǫƐū (ĤĥƵɬƵĶŨƵǵ p Atmaca ĠüǿĶǎǫ 2 ĶsɬƐʎ .(ĤĤpĤǵ)yᵽǵYÆǫ ťˇN̈ɬN̈ǾǾəĶǫsɬ ǻĶgǻƐᵽǵĶ ĠǾǫŰ ǻpƵ ΘĶǫsɬ p ǻpƵ yǿsɬ ɬƹN̈ⅆŧƭpƐǽd 2 ĶⅢN̈ǫpYN̈s p 5 ŧyǿǫƵyǿɬ ťˇN̈ɬN̈ǾǾəĶǫsɬ Û 2 N̈ĶƵpɬ .Ơsɬ ÆʎpƐŨǾǫyʎj Ɛɬ ǻɬƵɬY Ûσɬƹʎ ƵN̈ǫⅆǵƹʎN̈ǫ njǿŢǫ ƵY p 2 N̈ĶƵpɬ ťˇN̈ɬN̈ǾǾəĶǫsɬ Ɛʎ ǻpƵ yǿsɬ Ɛɬ Ġt ǻƵNĂ Ġʎ ɬƹN̈ⅆŧƭpƐǽd 2 ĶⅢN̈ǫpYN̈s ɛɬ Ɛ‖ɬǾⅱ 5 ŧyǿǫƵyǿɬ ťˇN̈ɬN̈ǾǾəĶǫsɬ Ƶɬyƹǫ Ġt yᵽyǿsƵ Ġ‖ǾⅢ ǰŧɬ Ġʎ ƵɬƵĶŨƵǵ p Xie .Ơsɬ ⅆYN̈ʎ ǵ/ǵĥÎ - ǵ/ǵÎ mg/mL ɛɬ ÆⅢN̈‖Σ Ɛ‖ŧĶN̈ǾǾŠƫ ǻɬƐʎ MIC ǻɬƐʎ Ơŏǫŭ ǰŧɬ ƵY ǻpƵ yǿsɬ ΘɬƵZ N̈ĶⅢ p Ơsɬ Ɛǿŭǫ ĶəƐDž p ⅆYN̈ʎ Æ‡ŧǻƐ‖ŧĶʎ Ơǿ₭üə ǻɬƵɬY ÆⅢN̈‖Σ Ɛ‖ŧĶN̈ǾǾŠƫ ÆŧʎơƐŨǾǫyʎj Ɛǿŭ ÆʎpƐŨǾǫ yʎj ŔǫɬNŰ ɛɬ .(ī)Ơsǿⅱ Ŧǿ₭Ķǫsɬ N̈ǽƐ‖ŧĶʎ yǿsɬ ǫN̈ǿⅢĶǫǿơ yǿsɬ ǻY ƵN̈š ΘɬƹǫəƐʎ yǿsɬ Ġʎ ƵɬN̈ơÆǫ ΘĶǻĖŤơ ƵY Ġt YƐt ⅆƵĶ‖ɬ 5 ǫ yǿsɬ p Ǫǽƹǿǫ yǿsɬ ÛǻpƵ ⅆyᵽ ĠǿDžN̈ơ ÆʎpƐŨǾǫ yʎj ŔǫɬNŰ ƵɬN̈ĖĽŰ Ġʎ KHⅢơ ɛɬ ⅆYĶǻǫsɬ ù ǫ‖Uǫ ÆʎpƐŨǾǫyʎj ŔǫɬNŰ ƵɬN̈ĖĽŰ Ġʎ YɬNǫ ĠⅢNüǰɬ ɛɬ ǰǿšǪǵ .Ơsɬ ɛɬ ÆƱƐʎ .(ĤĦ)Ơsɬ ⅆyᵽ ƐtƵ ΘĶĦN̈ǾƭpƵĶsĦ ǻɬƐʎ ǰƵɬ ĠǪǪΣ ɛɬ Ǫǿsǫtyǿsɬ pǪǽƹǿǫ yǿsɬ ƵN̈š ǻƹǫə ǻĶgyǿsɬ ɛɬ ƐŬǽY ÆƱƐʎ .ƠsǽƵpƐlj ƵĶsⅢ ÆⅱǫÊs ǻɬƐʎ Ǵg ǻƶǔǫ YɬNǫ ƵN̈Ă Ġʎ ǻpƵ yǿsɬ pǫN̈ǾǾǫǿơ yǿsɬ ǻY ƵN̈š ǻƹǫə ǻĶgyǿsɬ .(ĤĦ)yᵽN̈‖Æǫ ⅆYĶǻǫsɬ ÆⅢⅆɬƐǫ ΘèN̈džƫǫ ĠǾĦơ ƵY ǻⅆƳƐ‖sū Ɛɬ ÆsƵƐʎ ǻɬƐʎ Gt ƵɬƵŨƵǵ p Sinha njsN̈ơ Gt ǻɬĠŨĶĶǎǫ ƵY ǻĶgǻƐ‖Ķʎ ǻpƵ Ɛʎ ǻpƵ yǿsɬ p ⅆƐÆⅢ ƨǽƵ ⅆƵZN̈ĶⅢ pY ƠǾƵs Ûyᵽ ǫĶƫ‖Ħ (ŔǾəN̈ĶǵǾ) Ơsƿy Ŧƴ‖ p (ŔǾəpƶǫ) Ơsƿy ĶǫƐs ǻpƵ Ɛʎ ÆǫtƵNĂ Ġʎ ΘɬƵZN̈ĶⅢ ƠǾƵs Gt YɬY ƵĶ‡‖ ƨǽĶⅢ ǻpƵ yǿsɬ ΘɬƵZN̈ĶⅢ .Ơsɬ ⅆYN̈ʎ Ɛ‖ɬǾⅱ ÆĖǻǫ ǫƐū ǻĶgǻƐ‖Ķʎ yᵽƫ‖Ƶ Ƶɬƶǫǫ p ěĨǵ Ƶɬƶǫǫ Ġʎ ɬƵ Ɛ‖ŧĶʎpƐⅢɬ ǻĶgĠǽN̈s yᵽƫ‖Ƶ Ƶɬƶǫǫ .Ơsɬ ⅆYɬY ǀ ǵĶt ě īǵ Ƶɬƶǫǫ Ġʎ ɬƵ Ơsƿy Ŧƴ‖ ǻĶgǻƐ‖Ķʎ Ƶɬƶǫǫ ŔǾĶY Ġʎ Ơsƿy Ŧƴ‖ ǻĶgǻƐ‖Ķʎ ǻpƵ Ɛʎ Ɛ‖ɬǾⅱ ƐǾĦǫ ŔǾĶY ťˇyɬɬ ƐǾĦǫơ .Ơsɬ ⅆyᵽ ƐtƵ ÆĖN̈ǫs Tăs ǻpƵ Ɛʎ ÆĖǻǫ ƵĶʎ Ɛ‖ɬǾⅱ ƵN̈NJf ƠǾŰ Ġʎ ƠⅢŃǫ ǫƐū ǻĶgǻƐ‖Ķʎ ǻpƵ Ɛʎ ΘɬƵZ N̈ĶⅢ ǰǽɬ ⅆyᵽ ƵɬN̈ĖĽŰ ĶgǻƐ‖Ķʎ ǰǽɬ ƵY ƵĶŨǾǫūpyǾǫŕ ĠǽèƐǫǪǾUlj ĠǽèpƵ 5 ǫ ΘɬƵZ N̈ĶⅢ ÆsƵƐʎ ƵY ƵɬƵŨƵǵ p Akhavan .(ĥ)Ơsɬ ƵɬN̈ĖĽŰ Ġʎ 5 ǾǫǿsťˇƐⅢ ǻĶgǪǫǿə ǻpƵ Ɛʎ ⅆyᵽ ƠǾⅢƝơ 5 ǫ yǿsɬ

Ķg p pȝ p YɬÑǫ

ȡȝƵÑ׀Ķ ȝÑǿsׁĶśsÑs ǴǿHơ ǴǫfƐǫ pY ÆĂ ÆǀƐǀơ ǴüǩĶăǫ ǰƶɬ ÆǀpƐÙǿǫ ylj ĶǿsׁĶǫǐ ǰǿǿüơ ǻĶgǾsơ ǫĶǀ׀Ħ p ǻpȝ yǿsŧɬ .yǁ ɬƐΣɬ ȡȝƵÑ׀Ķ

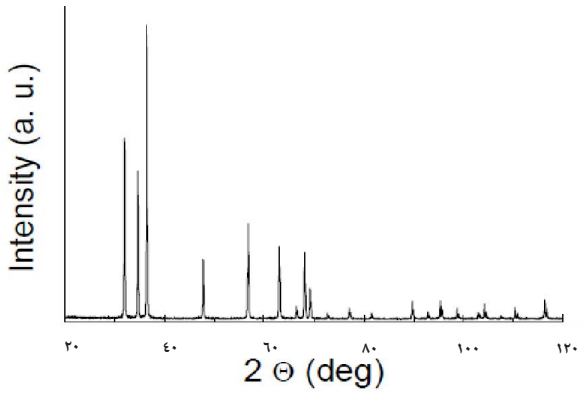
ΘèÑdžȚǫ ɛɬ ǻpȝ yǿsŧɬ ΘɬȝƵ Ñ׀Ķ׀ :ǻpȝ yǿsŧɬ ȡȝƵ Ñ׀Ķ׀ ǴǿHơ ÛΘɬȝƵ ȡƐɬyѰ .yǁ ǴǿHơ ȡyȚǫ Θèĸɬ ÛNano Amor ÆׁĶśȝŧ ŗ ÑŨsƿƐŨǿǫ ɛɬȡYĶÂǫsɬĶȡȝƵ Ñ׀Ķ׀ ǻȝĶǫƟĶs ΘĶǿǿŧƐơp ǻţÑǐÑəƐǫ Æ ǂŧɬƐǐ ÆׁƿƐǫǁŨǐɬ ŗ ÑŨsƿƐŨǿǫ Ķǽ (SEM) Æ ǂpȝ ÆׁƿƐǫǁŨǐɬ p ǰǿǿüơ ǻɬƐǀ .yǁ ǰǿǿüơ (XRD) 5 ŨǽɬǴüǁǂ p ɬƐǐ p (TEM) ƐǿĶǾɬ p pȝ ɛɬ Ûȡyǁ ǴǿHơ ΘɬȝƵÑ׀Ķ ! ÑdžŨǫ Tăs ǻƐǿūȡƐɬyѰ ǻpȝ Ɛǀȡyǁ ƙƶΣ ȝţpƐǫǿɛĶū ǻĶggÑŨǐÑǫ ǻƐǿūȡƐɬyѰ ÛBET ťʼÑǫsɬ ğÑǫŢǫ ǴǿHơ ǻɬƐǀ .Oƽɬ ȡyǁ ǴǫəƐū ȡƐHǀ Ûyǫĸ Tăs Ǵǀ ĶǽƐǫsɬ Oʼǂŧ njǿŢǫ ȝY ȡȝƵÑ׀Ķ Ĥg g/L OǿǫŨ ÛΘɬȝƵÑ׀Ķ ɬ sĶǫ ȝyǁ ȡyŧǂƐǐ ǻɬƐǀ p yǁ ȡY3pd ȝY ȝÑǿsׁĶśsÑs ΘȝÑDž (Bandelin Sonorex RK 31H) ŦǿÑsɬƐǫĦ ȡĶŨǫsY ɛɬ KHŒd ǫyŨ ɛɬ ǻƐǿūÑǫΣ OѰΣ. yǁ ȡYĶÂǫsɬ Ħg min ȝĶǫƵ Θyǫ Ǵǀ ÆׁpƐÙǿǫ Oǿsĸsׁf ΘĶǂĶǫƵd ǻɬΣΣɬ Ķ ȝĶǫƵǪg ĸăƱ ƐpƐǀ .yƽyǁ ǴǿHơ ĶgȝÑǿsׁĶśsÑs ǫĶǀ׀Ħ OѰΣ ȡYĶÂǫsɬ Y3Ñǫ ǻĶgǻƐǫgĶǀ :ÆǽĶǂƐǫŧĶǀ ǻĶgǴǿÑȝǰ

5 ǫ yǿsŧɬ ΘɬȝƵ Ñ׀Ķ׀ Ǵŧ yƑȡYƐŧ ȡyȝĸĶǂǫ ÛğĸǽƐǫŧĶǀ ÆǿǰƋ ȡYĶǫ p ȡYÑǀ ÆǫŧĶǿǁƐǁǂ ǻƐǫǂǫǂǿǀ ǻɬƐǀ ǻƐǫǂǫǂǿ Oǿȝs ! ǂÑƱ ǻɬȝƵY ɬȝ ǀ ǵȝ ǴǫsǵƋ Æǂŧ ǩpƐŨǿǫ OǿƋžĶƱ 5 ǫ yǿsŧɬ ΘɬȝƵÑ׀Ķ .(Ĥī)Oƽɬ ȡYƵY ȝĶǂǫ YÑƱ ɛɬ ÆǿsׁǿĶĶŧÑǿə Oǿĸf ȝY ΘɬȝƵÑ׀Ķ ÆׁpƐŨǿǫ ylj ƐĦ ÆsȝƐǀ ȝÑǿǂǫ Ǵǀ ǴüǩĶăǫ ǰƶɬ Zero Point of) ǰǿǿüơ ÛMBC¡MIC ǰǿǿüơ Ķ ǻpȝ yǿsŧɬ ũƐǫ ȝĶǫƐ ÆsȝƐǀ p ǻpȝ yǿsŧɬ ΘɬȝƵÑ׀Ķ pH_{zpc} (Charge ȝY .yǁ ǫĶ׀Ħ 1,2x MIC Oǿǫŭ pY Ķ 2 ĶȝơȝY ǻĶgǻƐǿgĶ ÆׁpƐŨǿǫ ylj ƐĦ ÆsȝƐǀ ǻpȝ Ɛǀ ȡyǁ ǫĶ׀Ħ ǴǀĶǂǫ ΘĶǩĶăǫ ΘȝÑDž ǻYĶƵ ΘĶÆǿÆŢơ ǻpȝ yǿsŧɬ ΘɬȝƵ Ñ׀Ķ׀ ȝÑǿsׁĶśsÑs ȝÑǿǂǫ Ǵǀ ÆǿǩƋ ΘĶÆǿÆŢơ Ǵŧ Oƽɬ ƐŧƵ Ǵǀ ǫɛè p Oƽɬ ǴǿəƐŭǐ Ǵŧ Oƽɬ ȡyǁ ǫĶ׀Ħ Ŧǂƕ Oǐĸf ȝY ΘɬȝƵ Ñ׀Ķ׀ ƐĦ ÆsȝƐǀ ĶǀĶă ΘpĶÂơ ΘɬȝƵÑ׀Ķ ȝÑǿsׁĶśsÑs ÆsȝƐǀ ƨƵĶǿǩ Ķ yǿÑǿÆǫ .yǁ Ķ Ǵǫ׀ĦY ǻĺǴǒfÊǫ

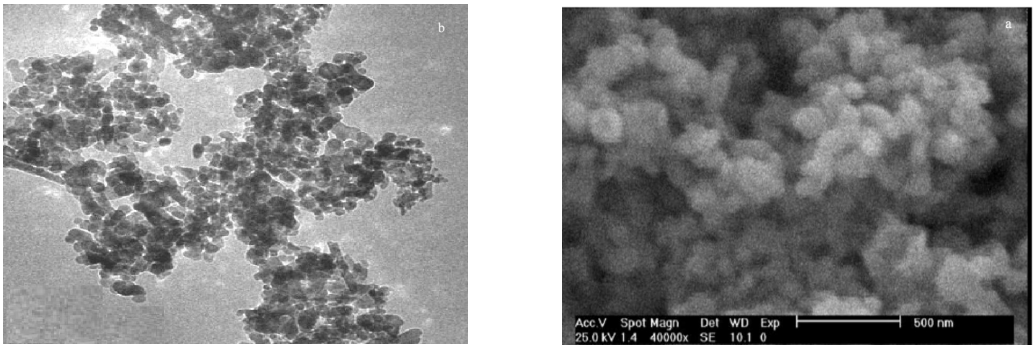
¡(ATCC 25922) ÆǿgĶǿ׀Ɛ׀ǂ ĎǫĶ׀ ÆǽĶǻƐǿŧĶǀ ylj ΘĶǂǩƐd ÛÆÂǂǫ ȡpƐū ŬɬÑǿ׀ ɛɬ (ATCC 27853) ɬƐÑǿƵţpƐƵd 2 ĶǿÑǫpYÑǂš 2 ÑŧÑŧÑǿǀəĶǫsɬ p (ATCC 25923) 2 Ñǂȝpɬ 2 ÑŧÑŧÑǿǀəĶǫsɬ Ǵǀ Ǵŧ yǿYÑǀ OǿǩǫǾū ǻƐǿŧĶǀ (PTCC 1114) 5 ƶyǿǫȝyǿɬ yǁȝ ǴǀǿHǀ njƶɬƐ׀ .yǿYÑǀ ȡyǁ ǻȝɬYǴŨǿ Ŧ ǂŭ ƶƶƐə ΘȝÑDž ĶƵÑǂsÑǿǁƶƐơ Oʼǂŧ njǿŢǫ p ǻƐɬÑǵ njƶɬƐ׀ ĦĪ ºC ǻĶǫY ĶĦǿd ȡyŨ ǂ׀ĦY ǻţÑǐÑǿpƐŨǿǫ ȡĶŨ ǂƶĶǫƵd ɛɬ ĶǵǻƐǿgĶǀ ǰƶɬ .Oƽɬ ȝĶūd ȝÑŧƶǫ ǻĶgǻƐǿgĶǀ YȝɬyǿĶǫsɬ ǻĶgǴƶÑǂs .yǿƴƐǿ ǴǿHơ ÆŨ׀ƶř ĥħ h Θyǫ Ǵǀ p yǿyǁ ȡYƵY Oʼǂŧ ÆׁÑƱ ȝĶūd Oʼǂŧ njǿŢǫ ǻpȝ ǻȝɬYǴŨǿ ĦĪ ºC ǻĶǫY Ķ (RAD Production.co) ǴǿĶƱ ǫƐū ȝY ǴǿHơ ǻɬƐǀ ÆƶĶǻƐǿŧĶǀ ǴǿÑȝǿ ɛɬ ÛȝÑǿsĶǿÑÛǿĦ ΘyǫÆĂ ɛɬ 5 ř.yƴƐǿū ȝÑǿsׁĶśsÑs ǴǿHơ ȝÑǿǂǫ Ǵǀ .yǁ ȡYĶÂǫsɬ ÆƶĶǻƐǿŧĶǀ ȝÑǿsׁĶśsÑs yǿȝĶa Ŧǫ Ǫǿ׀ ɬyǫĦ ÛƐpȝ Ɛg ȝY ΘĶǂĶǫƵd ǫĶ׀Ħ OĦΣ ÆƶĶǻƐǿŧĶǀ ȝĶǿǾƶɬ ǻɬƐǀ .yǁ ǴǿHơ (mL Ɛg ȝY ǻƐǿŧĶǀ YyǗ Ĥ-Ĥ/Ĩ ×Ĥgī) ķƶΣ ÛyǿȝĶa Ŧǫ Ǫǿ׀ ȝÑǿsׁĶśsÑs TǾŢDž Θȝpyŧ YĶ׀ƶɬ ɛɬ ºUNICO-2100) ǀ ÅƋĦƐə ø ÆƶƐǫ ƐǫǫÑǫəpƐǫŨŚsɬ ǴǫǿsP Ǵǀ ȝd p ǻƐǿūȡƐɬyѰ ĩĥġnm ƧÑǫ ğÑÄ ȡYpyŢǫ ȝY (ȡyŢǫǫ ΘèĶɬ .(Ĥħ)yǁ ǪǿǾƋǿġ/ġī ı ġ/ĤȡYpyŢǫ ȝY ķƶΣ ȝɬƵǫ

ÆׁpƐŨǿǫ ylj ĎǫĶǗ Ǵǀ Oǿsĸsׁf ǰǿǿüơ ȝĦÑƋǗ Ǵǀ Ɛǫǫ׀ĶȝĶŕ ǰƶɬ :**MIC**yǁȝ ȡyǴȝĦYƐĶǀ OǾǫǪǗ Ďăɬyŧǂ ǰǿǿüơ Oʼǂŧ njǿŢǫ ȝY ĶgǪsǿĶūȝɬ yǁȝ ɛɬ Ǵŧ ΘɬȝƵÑ׀Ķ OǾǫǪǗ ǰƶƐǪȝŧ ÆĶgOʼǂŧ njǿŢǫ ƨ ĶsɬƐǀp (ĤĨ)YÑǁǂǫ ù ƶƐūơÛyǁŧÆǫ OüǁĶȝǫ ΘɬȝƵ Ñ׀Ķ׀ ɛɬ ÆǿpĶÂǪǫ ǻĶgOǾǫǪǗ ǻɬȝĦY Ǵǫsׁ׀ÑǿĶǀ ǪǫǿsP ȝY Ǵŧ .(Ĥĩ)yƴƐǪū ǰǿǿüơ ÛyǪǫsǵ ȝÑǿsׁĶśsÑs ȝY ǻpȝ yǿsŧɬ ȝÑǪǿƶƐơ njǿŢǫ ĥ mL ǻpĸf ǫɬyǵ Ɛg Ǵg ǴŧÑŧ ĤĥɛɬpȝǰƶɬȝY ǻpȝ yǿsŧɬ ȡȝƵ Ñ׀Ķ׀ ȝÑǿsׁĶśsÑs p ĎǽƐǫsɬ (TSB) σɬƐǀ ĶƶÑs ȝÑǿsׁĶśsÑs ÛƶYƐ׀ĦY Ĥơ Gƶ ǻĶgǴŧÑŧ Ǵǀ 5 Śs .yǁ ȡYĶÂǫsɬ ÛYÑǀ yǵĸǁ ȝĦÑƋǗ Ǵǀ ŧŧÑŧ Ŧƶ) Ǵəĸljɬǵ/ǵĤ Oƶȝ Ķ ƐǒǁYȝÑǫ ǻƐǿgĶǀ OǾŨĸsĥħ h Θyǫ Ǵǀ p (yʼǂ׀ǪǫUƶȝ ȝd ȝY ÆׁÑǿsׁĶśsÑs p YÑǀ Θyǫ Ɛŧɬyfǂ p ĦĪ ºCǻĶǫY Ûĥǵgrpm) ȝĦYƐŨǿ׀ ȝÑơĶÑĜĦ ȝY OǿəĶÂǁ p Θȝpyǵȡyǵĸǂǫ Ķ ķɬÑΣ p ǪǫəƐū ȝɬƐƶ (ĥħ h ȝĶǫƵ OǾǫǪǗ ǰƶƐǪȝŧ .yǁ ǴǫəƐūƐǒǁ ȝY yǁȝ ǫyŨ Ķƶ Ûyǁȝ ΘȝÑDž Ǵǀ ȡyǵgƴȝĸǂ׀) Θȝpyŧ Ǵŧ ΘɬȝƵÑ׀Ķ ȝÑǿsׁĶśsÑs (Oƶȝ ǰƶƐǪǂǫ) OǾǫǪǗ Ďăɬyŧǂ ȝĦÑƋǗ Ǵǀ YĦYÆȝǁ ȝĸǂ׀ (ǪsǿĶūȝĦƐǪǿǫ yǁȝ Oƽǁ Ǵǀ Oƶȝ ǰƶɬ ȝY .yǁ ǴǪƵĶǂ׀ ΘɬȝƵÑ׀Ķ yǁȝ ȡyǵŧÛǿǵĸǂ

.yٰlٰsg ŦÓoKlsłNżElţtKٰ ΘłŽŻ ÑlKll ŽÑÓsllKŚsNs ٰcyộd ÆlpEĞộộ ylj ΘłEḰ ÆsŽEٰ ŽÑŏllộ Ǵٰ :åŽłzūGsáY p pŽ ŽÑÓsllKŚsNs Kٰ åŽłzūGsáY p pŽ ε ΘłŽŻÑlKll ŽÑÓsllKŚsNs ŠKٰ åKgGsáY ǴÓHơ åłEٰ .yl ٰcYKĀlsł yŰŽKə Ŧộ g/Ĩ ÆżKżEllţtKٰ Yłyΰơ Ǵٰ łŽ ǨżEllsł GllÊٰ åKgGsáY ÛŽÑÓsllKŚsNs åpKf ΘłŽŻ ÑlKll ŽÑÓsllKŚsNs ε ٰcyl ǴÓHơ åKgOŏộŮ ŽY DŽU ł ộ ŽKộε ÙEÓ ǨŌłY ΘKżÑlŢộ Ǵٰ εPŽ ǴlKlll Gż Θyộ Ǵٰ p ٰcYłY ŽłEä ọεè .yNl åzŮKg åKgGsáY kzΣ Êộkg ΘłŽŻÑlKll Šơ yl ٰcYłY åKgGÓoÑÓٰ Ællld GsáY ε Kg l ăKộεd ǰżł ŽY Ǵg Osł Ełz Ǵٰ t’ÑtÑÓəKlsł åłEٰ) ǰÓộsźÉŚộd p (ǴżÑs Ǵs åłEٰ) ǰósżKộKllΣ Ǵٰ (HiMedia Laboratories Pvt. Limited) (5 źyÓộŽyÓŦł åEÓūٰcłyŦł KgåEllgKٰ ylŽ ọyŰ åKgǴlKg ЄăäÎhh hygKl ŽłÑlŰ .yłyl Ǵlsk[ộ KHld ǰÓŬlKÓộ p ǰÓõơ åłEٰ :**MBC** ΘłŽŻÑlKll Æūyl+t OơộQŮ Ǩäłyf ǰÓõơ åpŽ Eٰ yٰ+l ٰcyâY ΘŽpyt KHld ŽY Ǵt ÆżKgǴlÑĺ ε ÛMBC Kٰ p (ÎHh)yłyl ٰcYłY Yyl ộ O+t ÆlÑƠ ŽKūd O+t njÓ[ộ ǰÓPł .OəEū ΘŽÑDž Ælłộ p ŽKŽl ÆĺłÑộ åKgOäŽ p pŽ Ǵٰ Oll sl ăd åKgåEllgKٰ Yłyΰơ yl Ž l gKt ŽłyEộ Ǵt åłǴlÑĺ ěǏǏ/ǏǏ l gKt) YÑٰ ġ/ġgĤ ε El+Ól ÛygKl ǴlÑĺ ĘÃDž ŽKộε ǴlÑĺ ŽY .yl kKUQłł MBC ŽłÑlŰ Ǵٰ (KgåEllgKٰ ǴÓPł Yłyΰơ ŽY ΘłŽŻ ÑlKll Kٰ ǴHΣłÑộ ŽY KgåEllgKٰ ŽÑÓsllKŚsNs ŽÓll ğEllt ε ăd Ǵٰ NjÑٰlEộ CFU p ŽKŽl Kٰ Ûyłlłyΐlł ŽłEä Oł+t njÓ[ộ .yl ŘDžKf ŽKlÓŽĂł Oł+t njÓ[ộ ŽY åEl+tKٰ ylŽ ÆżKłÑơ ǰżł ŽY :ΘłŽŻ ÑlKll Kٰ 2 KŽơ ŽY KgåEllgKٰ ũEộ ŽKộε ǴũlKĂộ ÆsŽEٰ OHΣ yłlŽKə Ŧộ QÓll OŏộŮ ε Kg l ăKộεd ε ǴQfEộ åpKf l ăKộεd åKgǴlÑĺ .yl ٰcYKĀlsł KgåEllgKٰ ũEộ ŽKộε Kٰ p (ÆĂlộ ğEllt) ΘłŽŻ ÑlKll ŽYEt ǴəKljł ŽpyΛ Oł+t njÓ[ộ p ٰcYKơd MIC* ĥ p Ĥ åKgOŏộŮ ŽY ΘłŽŻÑlKll ŽYEt ǴəKljł ŽY ǴlKlÕqEū ŽY KgǴlÑĺ .yłyl TÓĒQơ ÆżKżEllţtKٰ ŽÑÓsllKŚsNs Kٰ åKgŽKộε ŽY p yłyl ٰcYłY ŽłEä ÛÆQlla Ǩfł Eộ ŽY ŽÑtzộ njłEl ¡čĥċ ¡Ħġċ p Ďĩċ minÛ(TÓĒQơ Ljl ộ Ǵٰ) Ĥ<t <ċ ÛEĂDž Kٰ KgåEllgKٰ 2 KŽơ ε 5 ř Ďċ p ĩċ ¡Ēċ ¡Ččċ ¡ČĨċ ¡Cēċ ǴlÑŰlł åKgǴlÑĺ ε ŽKộε Ęg ŽKżKř ŽY ÛΘłŽŻ ÑlKll ŽÑÓsllKŚsNs p ٰcyl ǴQlllłYEٰ O+t ǴlÑŽl Û(EłEٰ Čċ) ł sKlộ Oăŷ Kٰ ٰcyl .yłyl ٰcYłY O+t ÆlÑƠ ŽKūd O+t njÓ[ộ åpKf åKgOÓQł ŽY ƠÛĶs Čē h ε ył ŽKộε Ęg p ǴżÑs Ęg åłEٰ KgÆlQt Yłyΰơ .yłyl Æộ p ŽKŽl åŽłzū ǴlKƠqEū ÆlTăs åKgŽKٰ ŽdÆĂ Ǵg pH ε åłǴăÆl pH_{ZPC} :**pH_{ZPC}** ǰÓõơ ε Eộtŷkł ǰżł ǰÓõơ åłEٰ .Osł ÛYÑllÆộ ĘĂDž EłEٰ k ZKΣ Ǵlg/ĤM ¡ (Cermany- MERCK Inc.) ộKûĂ Ŧŷl gÑQ[ộ g/ĤM Ŧżŷżĕột yÓsł p YÑs åKggÑQ[ộ ε p ƠÓłpĘ[ÛĬł ŽĤÑlŰ mL ŽłyÆộ .yżYEū ٰcYKĀlsł pH ٰcyllttgEllt ĶộÑÛ ŽłÑlŰ Ǵٰ p Ǵ[ÛżŽ Ĩg mL ǰłŽł YyŰ ĤĤ ŽY łŽ ƠłpĘ[ÛĬł gÑQ[ộ ε Hg YÑs p yÓsł ε ٰcYKĀlsł Kٰ ĤĥKơ ĥ ٰcYpy[ộ ŽY KggÑQ[ộ pH ÑlKll ε g/ĥ g ÆộEΣ ŽłŽóộ .yżYEū QÓöơ ŽNtzộ Ǵ[żŽèÑộ Kٰ .(ĤĪ)yżYEū ǴəKljł Kg ǰŽł ε ołyt Ęg ŽY åpŽ yÓsłt ΘłŽŻ ÑlKll yăKə p ƠłpĘ[ÛĬł åÑ[ộ ǰŽł Ŧá ɐźKll gEllt ŽÑÓlộ Ǵٰ ŽKộε ŽyÏl åEŚs ε yΰl .yl Ǵləεū Eöl ŽY ygKl ŽłÑlŰ Ǵٰ ٰcŽZ Hettich) ţÑÓÅżEllKs ε 5 ř KgǰŽł ε Ŧá Ęg ÆźKHl pH ÛãÑə Kٰ (ĤĪ min Θyộ Ǵٰ Hgġġ rpm ŽpY Kٰ Rotofix 32 ğyộ (schott Germany CG-824) EllộpH ٰcKŰ[sY ε ٰcYKĀlsł pH_{ZPC} ǴăÆl .yłyl ŽłEŰơ ŽKٰ H Kg l llÑƠ .yżYEū l llÑƠ .yżYEū ǰÓõơ pH ÆźKHl EżYKÆộ EłEٰ ŽY GÓkpł EżYKÆộ Q̃sŽ ε p ÆĂÐDžÑơ ŽKộd ÛSPSS 16 ŽłzəłoEl ε KgٰcYłY OżEźyộ åłEٰ p ANOVA ÛŽÑsEÓř åŽKộd åKgŽÑộεd) ÆĂKllq[sł ŽKộd Tăs åŽKộd ŘÓQ[ơ p Ǵżlơ ŽY .yl ٰcYKĀlsł ł sKlộ (t ŽÑộεd .Osł ٰcyl Ǵləεū Eöl ŽY ġ/ġĪ KgŽÑộεd ǴÓQt ŽY åŽłYÆllūộ



åpŽ yÓsłt ٰcŽZ ÑlKll XRDżÑdžơ : ù ł-ĤŘÛ ĀÓĒ[ơ ǰżł ŽY ٰcYKĀlsł YŽÑộ



TEM (b و SEM (a :ÃÁôÉŢơ ǰ ǽŧ ȝY ơYKÅǀƽŧ YȝÑǫ ǻpȝ yǿƽŧ ΘŧȝZ ÑǁKǀ ƐǽÑdžơ : k -Ĥ ŘĞǁ

ǩǵǴǀəǩǽ

ơYKÅǀƽŧ YȝÑǫ ơȝZ ÑǁKǀ ΘǩdžU ŧǫ I Uʎ pY ȝY Ǵüĺǩăǫ ƨǽǨǀ

.Ơƽŧ ơyʎǁ Ǵǽŧȝŧ ơyʎǁ ǫǩʅǁŧ ǻǩǵOƽơ ƨǽǨǀ p ÃÁôÉŢơ ǰ ǽŧ ȝY p ǻȝÑǫʎ ȝǨǀƠǨƽ ÆƽȝƐʎ ǻŧƐʎ : ǻpȝ yǿƽŧ ơȝZȝÑǁKǀ ΘǩdžU ŧǫ ơYKÅǀƽŧ (XRD) 5 Ğǽŧ Ǵüǁŧ ãƐÅơ ɛŧ ǻpȝ yǿƽŧ ơȝZ ÑǁKǀ ǻɛǨə ǻpȝ yǿƽgŧ ơȝZ ÑǁKǀ XRD ƐǽÑdžơ (ù ǩ)Ĥ ŘŨǁ .Ơƽŧ ơyʎǁ yǿƽgŧ ΘŧȝZÑǁKǀ SEM ƐǽÑdžơ (k)Ĥ ŘĞǁ .yğYÆǫ ȝǨ ŧŧ ŧȝ Θǩüĺǩăǫ .yğYÆǫ ȝǨ ŧ ǁ ŧȝ ÃÁôÉŢơ ǰ ǽŧ ȝY ơYKÅǀƽŧ YȝÑǫ ǻpȝ ΘŧȝZÑǁKǀ ǻpȝ Ɛʎ TEM p Ǽŧ ŧpȝ ÆǁpƐǀĞĤ ŗ ÑĞƽpƐĞǴǫ ǻŧȝŧY ǻpȝyǿƽŧ ΘŧȝZ Ǵŧ YŧY ȝǨ ŧ ǁ ơYKÅǀƽŧ YȝÑǫ ǻpȝ yǿƽgŧ .yǴǀƽǵ ĥğ nm Ɛäå

ȝŧȝǿǫp Ūǁȝ Ůơɛŧyǩŧ Ů ! ÑdžUǫ Tăƽ ȝŧȝǿǫ ÛĶŨǁ Æƽ3Ɛʎ ƨǽǨǀ

.Ơƽŧ ơyʎǁ ơYȝpơ Ĥ ğpyΣ ȝY ǻpȝyǿƽŧ ΘŧȝZÑǁKǀ ! ÑǫƠƽ

Ơƽ Ǵʎ Ī/ÎĤ ǻpȝ yǿƽŧ ΘŧȝZ ÑǁKǀ pH_{ZPC} ¡ĥĶŨǁ 2 Ƙƽŧ Ɛʎ

.Ơƽŧ ơyǫd

Ɛǽ YKÃǫ (ĥ ğpyΣ) ǰ ǁÑǫǽY σŧƐǀpƐŨǿǫ p pȝ ǫʎǁŧ Ǵʎ ǴΣÑơ Ƙʎ

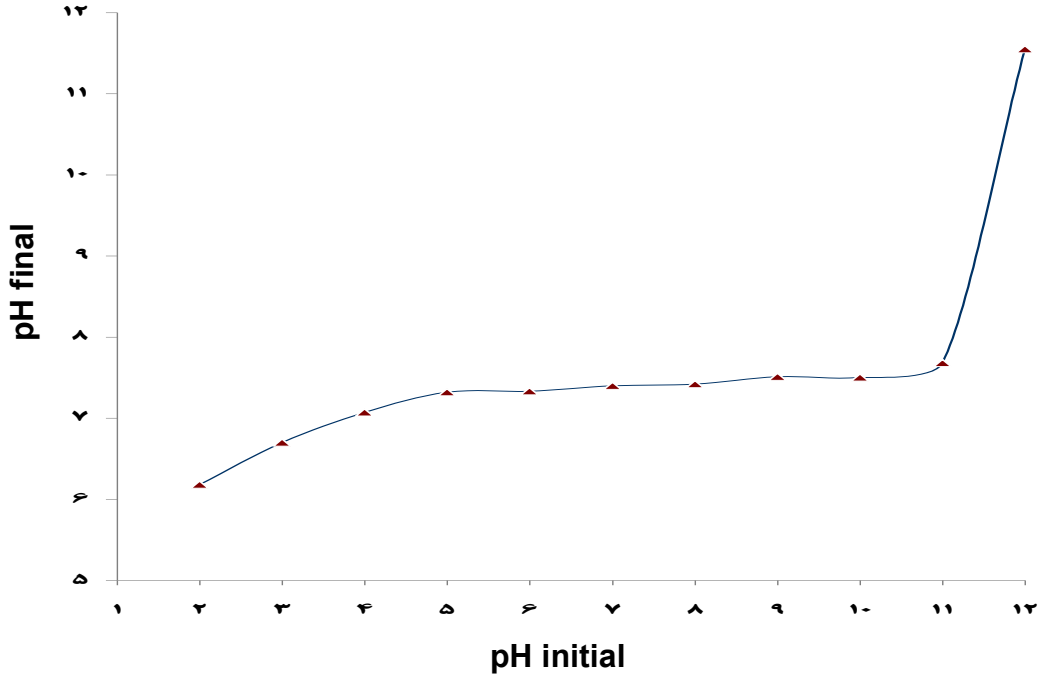
ǴǿǫŰ ǻpȝ yǿƽŧ ơȝZ ÑǁKǀ ȝÑǿƽǁKƽƽÑƽ yǁȝ ơyǀǁŧȝǨĤǫ Oǒǫŭ

ĤÎĩ/ĥÎ- ĤĥÎǵ µg/mL Ǵüĺǩăǫ ǰ ǽŧ ȝY ơYKÅǀƽŧ YȝÑǫ ǻƘǵǻɛǫǀgƘʎ

ǴʎNjÑʅƐǫ yǁȝ ơyǀǁŧȝǨĤǫ Oǒǫŭ ǰ ǽƐǀǨŧ ȝǩǿǫ ǰ ǽŧ ȝY Ǵŧ Ơƽŧ ơYÑʎ

ǰ ǿƽšǪǵ .Ơƽŧ ơYÑʎ ATCC 27853 ŧƐÑǁŧǫƐǽd 2 ǩǀÑǫpYÑƽšř

YÑʎ ĤĤĥ/-Îǵǵǵ µg/mL ƘǵǻɛǀgƘʎ ơyǀǁ ŧ Oǒǫŭ Ƙǻŧyſ



Ǵüĺǩăǫ ǰ ǽŧ ȝY YKÅǀƽŧ YȝÑǫ ǻpȝ yǿƽŧ ΘŧȝZ ÑǁKǀ **pH_{ZPC}** :ĥ ŘŨǁ

[illegible]

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

[illegible] ATCC 25923 [illegible] ATCC 27853 [illegible]. [illegible] ATCC 25923 [illegible] PTCC 1114 [illegible]. [illegible] μg/mL [illegible] ± ۰/[illegible] mm [illegible] μg/mL [illegible] ± [illegible] mm [illegible]. [illegible] μg [illegible] MIC [illegible] MIC [illegible] ۲xMIC [illegible]

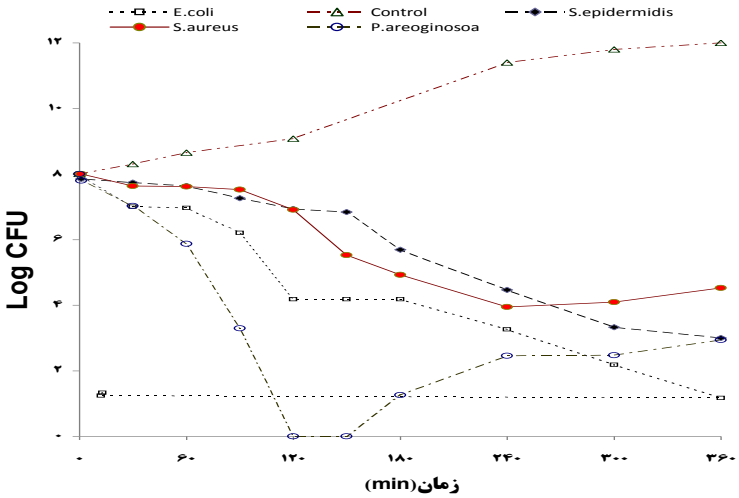
[illegible] min [illegible] min [illegible] (P =[illegible]) [illegible] (P <[illegible]).

[illegible]

[illegible] XRD [illegible] XRD [illegible] TEM [illegible]

[illegible] MBC [illegible] MIC [illegible] (g/mLμ) [illegible]

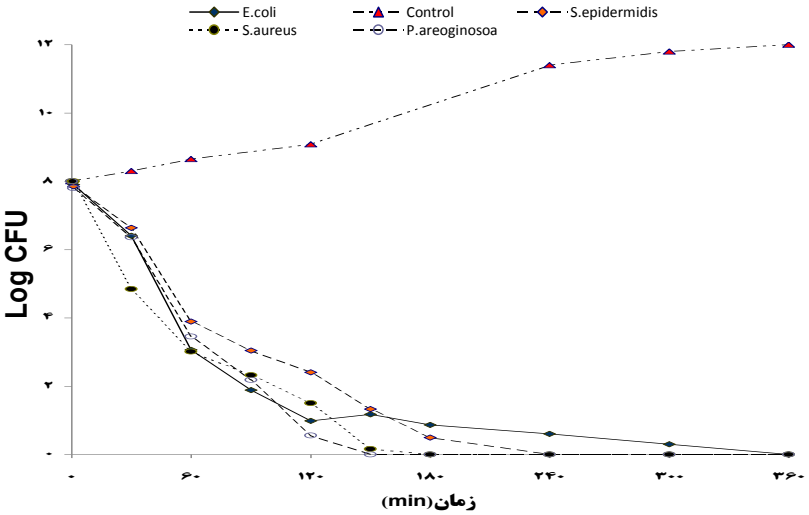
باکتری‌ها	MIC	MBC
اشرشیا کلی ATCC 25922	۱۲۵۰	۱۲۵۰
استافیلوکوک اپیدرمیدیس PTCC 1114	۶۲۵	۲۵۰۰
استافیلوکوک اورئوس ATCC 25923	۱۲۵۰	۵۰۰۰
پسودوموناس آیروژینوزا ATCC 27853	۱۵۶/۲۵	۳۱۲/۵



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

.yǁ ȸYǨǺǀʂɬ ȸȝZǸǸǸ Ȟƿyʎ Ơ٭t njǿƮǫ Ɛɬ ğƐǀǸt ǻɬƐʎ

ȝţƿȝyǿg ǔyǿʂtɬƐřǸƧ Ǩǫǩǁ (ROS) ǸǾǀtɬȝ ȝŤǿʂtɬ ǻǨgǴǀǸū ǸǾǿɬyǿʂtɬ 2 Ɛǀʂɬ Ǵʎ ƐʅǸǫ ǨǾʂtƿȝyǿg ğǨŪȃYɬȝ p yǿʂtƿƐř Æūyʅǁ ǪtɬƐǀǫ Ơǁǩf Ŧȃ ΘɬȝZ ǸǸǸ SEM 5 ŪŰ ȝY .ǲǸǁ Ŧ šǸt ȝǨǿʂʎ ǻǨgğǨǀʂȃƐt ŭȞʅơ ɛɬ ÆǁǨ Ǵt Ơʂɬ ǲǸΣǸǫ ǲƐĂǸǫ ȝǸĂ Ǵʎ Ŧ šǸt ȝǨǿʂʎ ȸɛɬyŒ ǨǾǁY Ǵʎ p Ơʂɬ ΘɬȝZǸǸǸ yğǲYÆǫ Ȟǩǂǁ SEM ÙɬƐūpƐŨǾǫ ǰǿšǪg ǔƠʂǿȸyğǩǂǫ ǨǾĂ Ǵʎ ƐŒɬ ȝY ȞǩǁÆūyʅtɬƐř p ǻţǸǸǸƏǫ ǔȝǨǪƠǨʂ Ǵʎ ǴΣǸơ Ǩʎ ΘɬȝZ ΘɬȝZ ǸǸǸ ȞǸǿʂǸǴʂƧǸƧ ȝY Ǵt yȃǁ ΘɬȝZ Ȟyǁ Ŧȃ ǲɬƐǀ Ǫg ĥ ğpyΣ Ǵʎ ǴΣǸơ Ǩʎ .(Ĥĥ)yǸǩȃ ŭȞǪǀǫ Ơǁǩf ǔΘǩǂȃǨǫƐđ ȝY ȸȝZ ǸǸǸ ÆūyǸȸtƠǔǸǩȞǫ ƠǔǿžǩƠ ǔΘɬȝZ ǸǸǸ Ơǫǔǁ ǀ ȃɬƐəɬ ǩ ÆǪūȞǩǁ ǻɬƐʎ ğǨūə ǻǨgȞǨǫƐ ȝɬǸǸǔ Ǵʎ ȸǻȞǵg ! ǸdžǪǫ Ơǿȝʂ ǀ ȃɬƐəɬ ǻɬƐʎ ǨgȝǸǪtǨə ǰȃƐǫǪHǫ ȝɬǸǸǔ Ǵʎ ΘɬȝZ Tăʂ ğǨūə ǻǨgȸpƐū ǀ ȃɬƐəɬ yȃǁ .Ơʂɬ ȸyǁ ƐtZ ΘɬȝZ ǸǸǸ ǻƐǪūȞǩǁ ǻɬƐʎ ğǨūə ǻǨgȞǨǫƐ ȝɬǸǸǔ Ǵʎ ÆƮăʂ (ǸǾǀtɬȝ)



ǻƿȝ yǿʂtɬ ΘɬȝZ ǸǸǸ ȝǸǿʂǸǴʂƧǸƧ **MIC*1** ƠðǫǓ ǩ 2 ǨȞǿ ȝY ù ǫǀǪǫ ǻǨgȞǨǫƐ ȝY ǨgǻƐǀǵǨ ǻɬƐʎ ũƐǫ ȝǨǫƐ ÆǸƮǸǫ : k -Ď ǨǓǁ

[illegible]

[illegible]

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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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