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ANTIMICROBIAL ACTIVITY OF GREEN-SYNTHESIZED ZnO NANOPARTICLES DOPED WITH PRASEODYMIUM

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INTRODUCTION & AIM

Antimicrobial resistance is a serious obstacle in the fight against pathogenic bacteria. One of the solutions would be the use of nanoparticles (NPs). The antimicrobial action of NPs is mainly due to the generation of oxidative radicals (ROS), resulting in destruction of macromolecules from all cellular structures. This mechanism is non-specific and does not allow microorganisms to easily develop resistance. Bacteria have innate antioxidant systems to deal with ROS – non-enzymatic (e.g. glutathione, flavonoids, vitamins) and enzymatic (superoxide dismutase (SOD), catalase (CAT), oxidase and peroxidase), which neutralize toxic oxygen species. However, upon exposure to nanoparticles, the accumulation of ROS overcomes cell defenses and induces oxidative damage.

Green synthesis of NPs is a promising more environmentally friendly, safe, economical and biocompatible technology. In this study, the antimicrobial activity of ZnO NPs prepared via a green approach mediated by *Lavandula angustifolia* and *Thymus* sp. (undoped and doped with praseodymium) was evaluated. Praseodymium (Pr) is an element from the lanthanide group, which use in the synthesis of NPs is a new trend. It is believed that Pr doping contributes to the production of smaller sized NPs, therefore enhancing ROS generation, leading to better antimicrobial activity.

METHOD

- Synthesis method: The ZnO nanoparticles (named as L3 and T3) were produced by essential oils (Lavender or Thyme oils) mediated green synthesis using Pluronic-assisted co-precipitation followed by calcination at 500°C. One part of the ZnO particles were doped with Pr_2O_3 (L4 and T4).

- Microorganisms: Gram(-): *Aeromonas caviae, Escherihia coli, Klebsiella oxytoca, Klebsiella pneumoniae, Pseudomonas aeruginosa, Salmonella enterica*; Gram(+): *Erysipelothrix rhusiopathiae, Bacillus subtilis, Bacillus cereus, Oerskovia paurometabola*
- Cultivation: 24 hour cultures in Mueller Hinton Broth, 37°C, rotary shaker 200 rpm
- Microtitre plate-based antibacterial assay incorporating resazurin (Sarker et al., 2007)

RESULTS & DISCUSSION

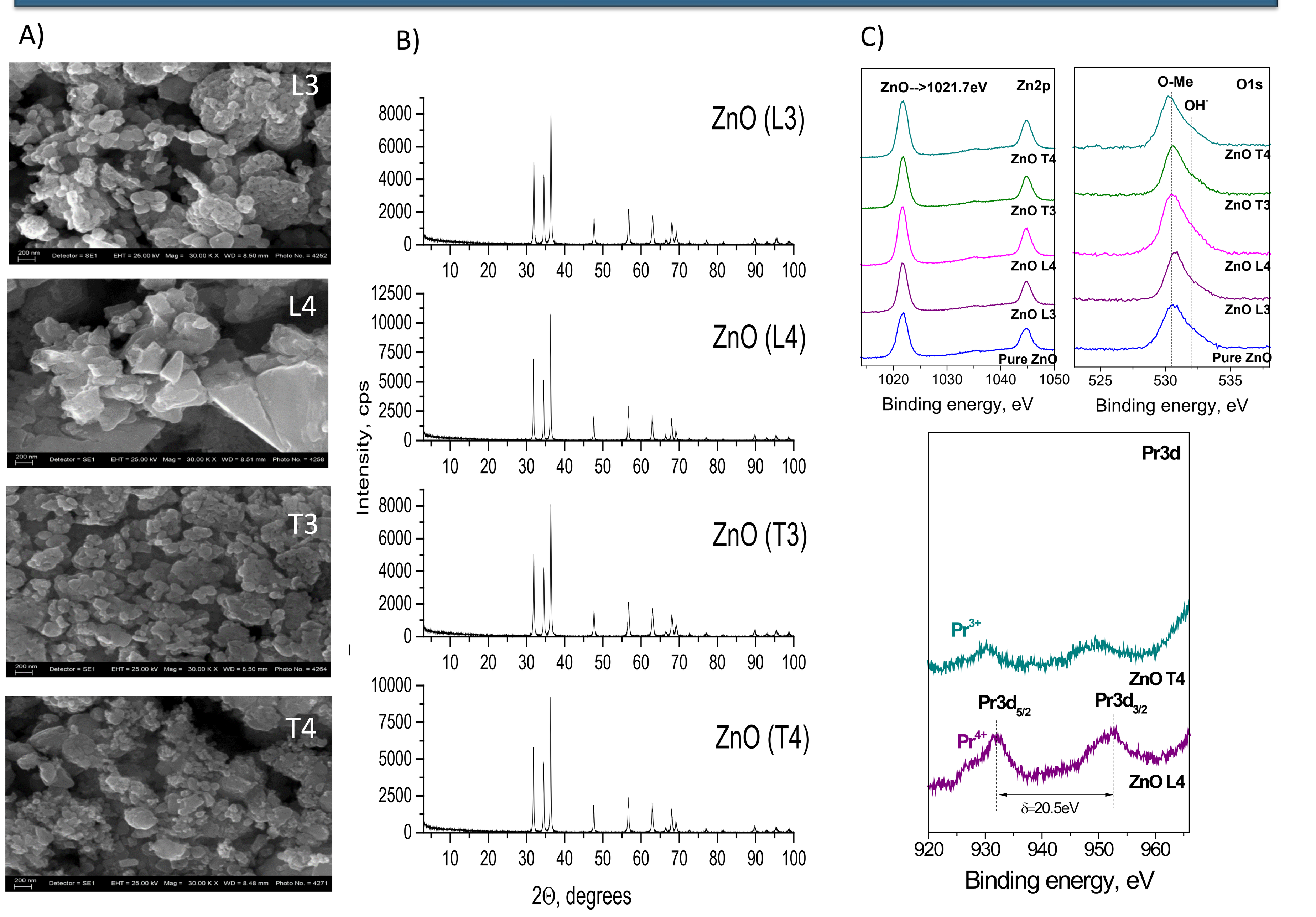

Figure 1. Characterization of the synthesized ZnO NPs: A) SEM images; B) PXRD patterns; C) Core level spectra of O1s, Zn2p and Pr3d of ZnO nanopowders.

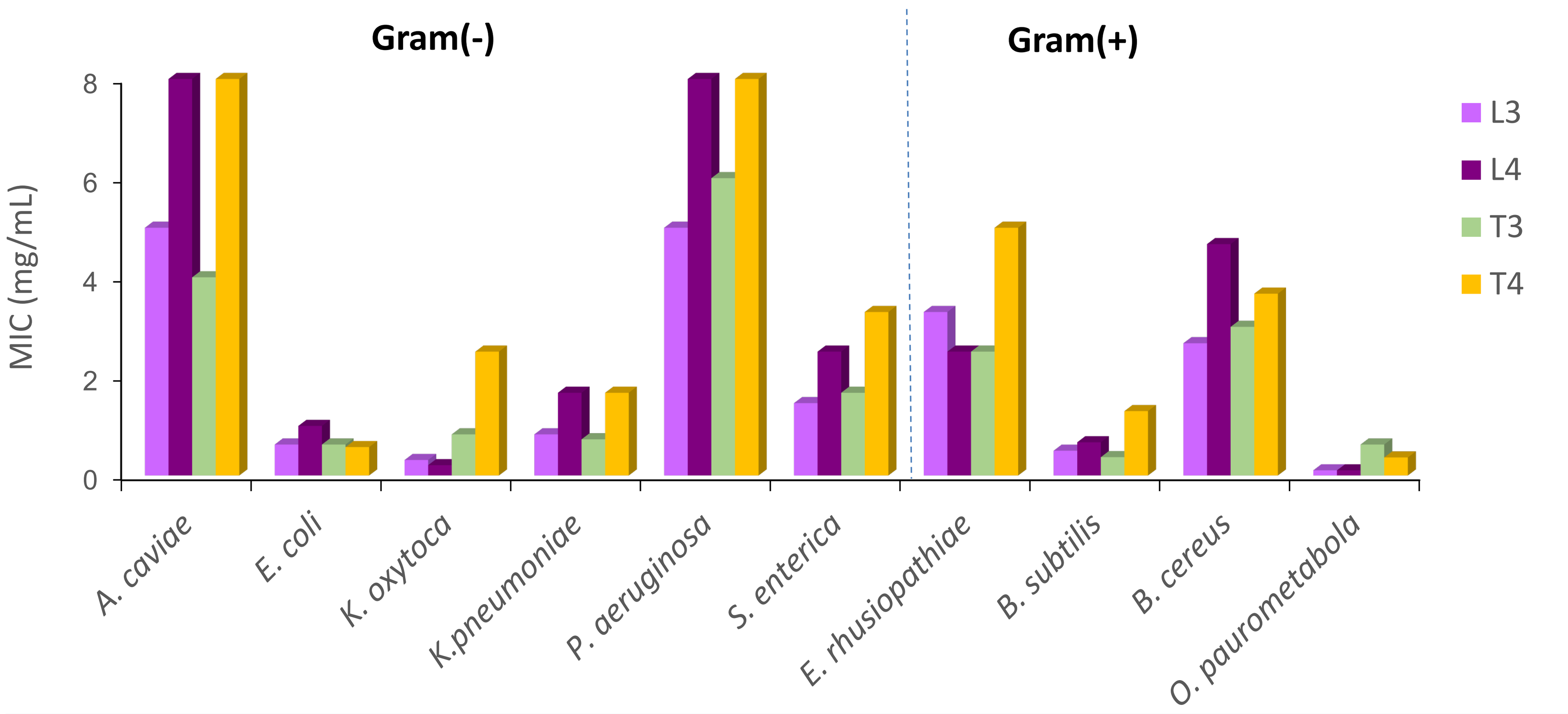

Figure 2. MIC values of the tested doped and undoped ZnO NPs on test Gram(-) and Gram (+) bacteria

- The non-Pr-doped particles have a better effect than the doped ones. Materials with more irregular particle shapes and sizes have higher MICs (Figure 2.).
- Gram(+) bacteria are more sensitive to the ZnO NPs than Gram(-).
- Higher MICs were observed for bacteria from Risk group 2. This effect may be due to their better antioxidant protection, as it is a factor for successful infection of the host, and the antimicrobial effect of metal oxide NPs is a result of their ability to generate ROS.

Table 1. MIC values for each NP type and for each bacterium

Microorganisms	Gram	Risk group	MIC, mg/mL				Average MIC for bacterium
			L3	L4	T3	T4	
A. caviae	-	2	5	8	4	8	5,1
E. coli	-	1	0,63	1	0,63	0,58	0,63
K. oxytoca	-	2	0,31	0,21	0,83	2,5	1,02
K. pneumoniae	-	2	0,8	1,67	0,73	1,67	1,38
P. aeruginosa	-	2	5	8	6	8	5,5
S. enterica	-	2	1,5	2,5	1,67	3,3	1,7
B. subtilis	+	1	0,5	0,67	0,37	1,3	0,57
B. cereus	+	2	2, 7	4,67	3	3,67	3,05
E. rhusiopathiae	+	2	3,3	2,5	2,5	5	3,16
O. paurometabola	+	1	0,10	0,10	0,63	0,37	0,26
Average MIC for type of nanoparticle			1,26	1,9	1,4	2,54	

- The average MIC value is lowest for L3. The comparative antimicrobial effect of the NPs tested here can be expressed as follows: L3>T3>L4>T4 (Table 1).
- The highest MIC values are observed for *A. caviae* and *P. aeruginosa*

CONCLUSION

- The tested green-synthesized ZnO-NPs have the potential to be used as antimicrobial agents against a wide range of Gram (-) and Gram (+) bacteria with pathogenic potential.
- To enhance the effect of praseodymium-doped nanoparticles, it is necessary to achieve their production in smaller sizes.
- Pr doping leads to reduction of the average crystallite size. The mean crystallite size of ZnO phase is 60 nm L3; 52 nm in sample T3 31 nm for L4; and 18 nm for T4 determined by PXRD analysis.

FUTURE WORK / REFERENCES

It is planned to use other elements from the lanthanide group as dopants and test the antimicrobial effect of the doped NPs.

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