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Synthesis and antibacterial properties of ZnO:Ag films prepared from a Triton^{MR} containing solution

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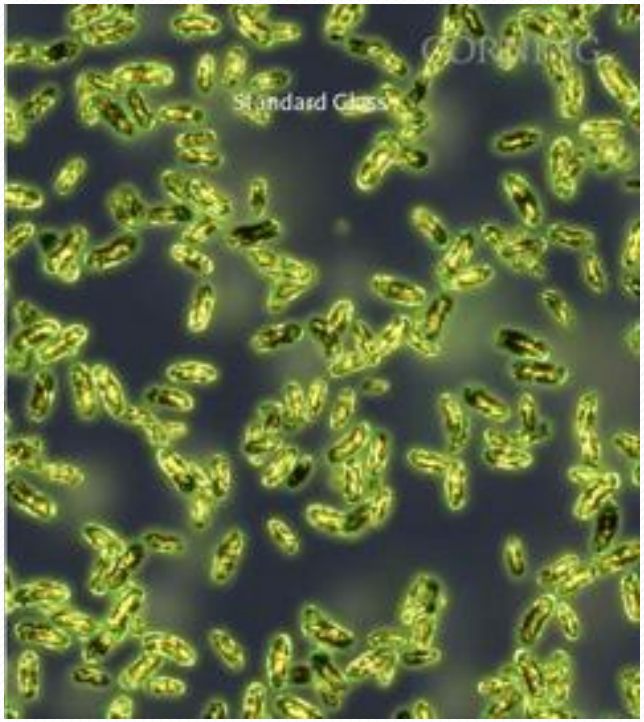
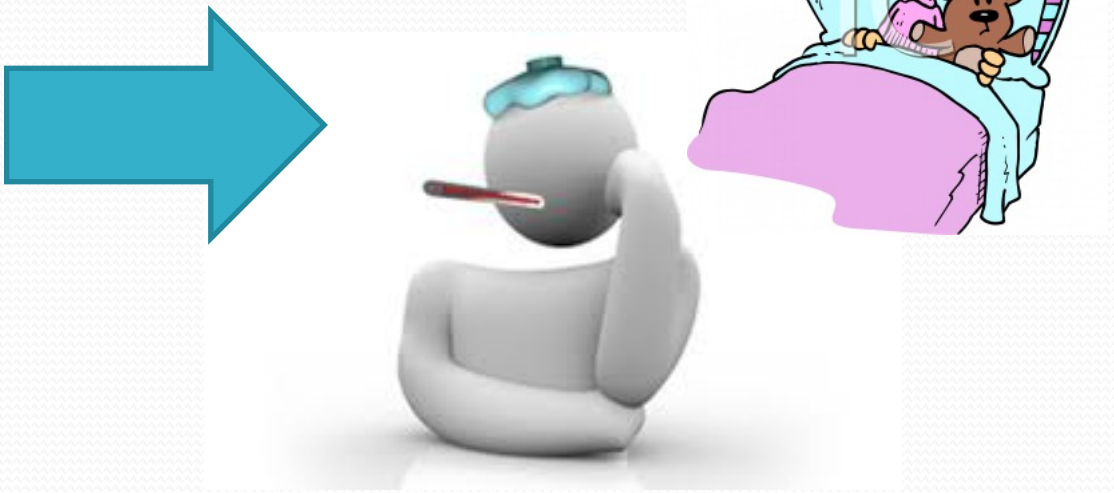
Introduction

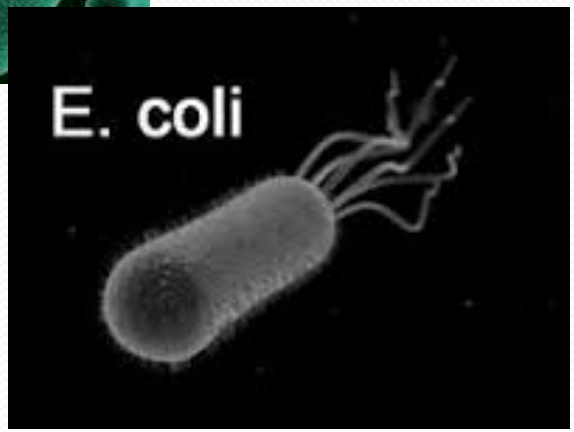
Thousands of bacteria live on surface of common glass¡¡





http://anewdomain.net/wp-content/uploads/2014/01/Corning-Gorilla-Glass-microbes.jpg

- Certain nosocomial pathogens can contaminate hospital surfaces, cell phones, windows, refractories elements, other glass elements, wood, etc, can survive for extended periods.
- *E. Colli*
- *S. Aureus*
- *P. Aeroginosa*
- *C. Difficile*
- *E. Typhosa*
- *B. Subtilis*
- *Etc*



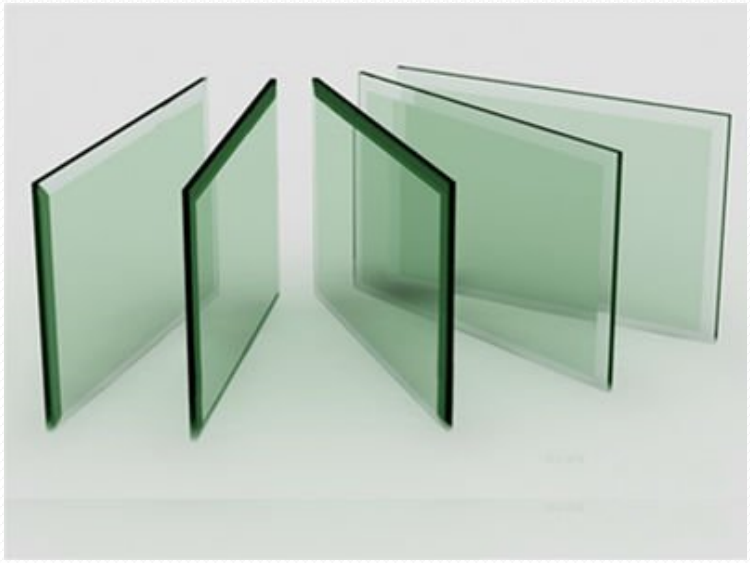
- The “”Global Antibacterial Glasss Market 2014-2018" report to that **Global Antibacterial Glass market to grow at a 6.39** percent over the period 2013-2018.

The major reason behind this growth is the increased number of instances of food poisoning

(http://www.researchandmarkets.com/research/cb62lj/global)

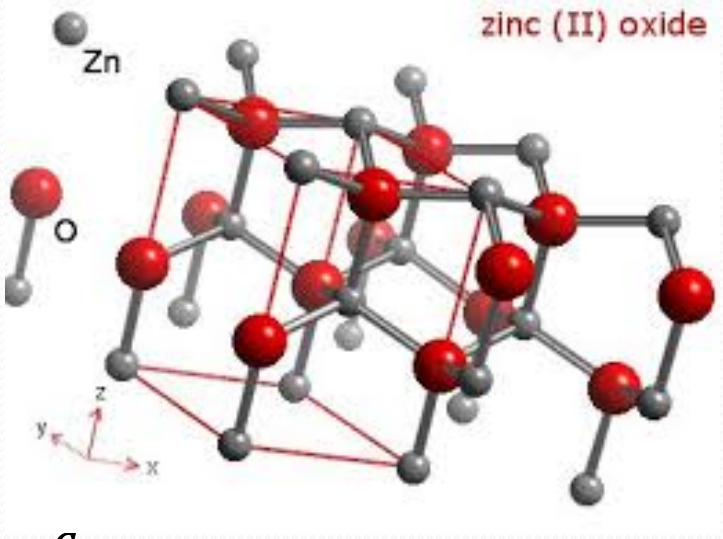
Aim

- “Prepare sol-gel derived ZnO:Ag films on glass substrates with antibacterial properties using Triton X-100 as sol-stabilizer”

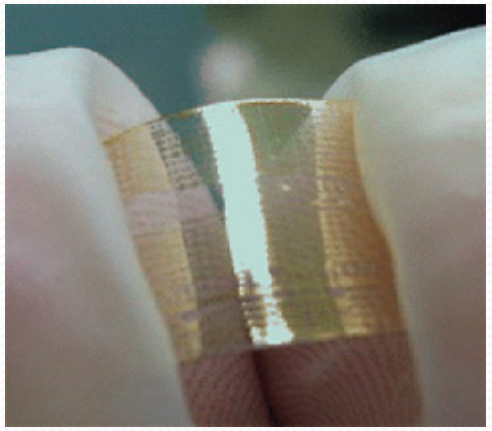


ZnO properties

- Transparent ceramic material
- High thermal and chemical stability
- Good mechanical properties
- Wurtzite-type structure
- Capacity to inhibit the growth of microorganisms and act as a high-range antibacterial agent*
- Ag-doped, outstanding microbicidal properties



www.webelements.com



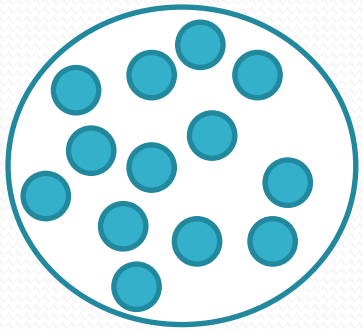
www.oit.ac.jp/english/research/microdevice.html

* Azizi, S.; et. al, Nanoparticles. Molecules 2013, 18, 6269-6280.

Sol-gel method

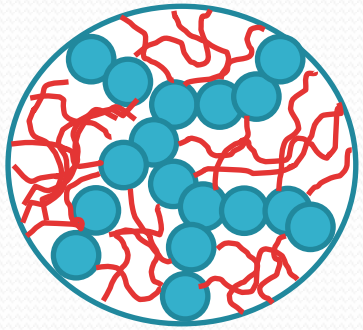
- Particular efficient preparing oxide films
- Relative low cost
- Easy set-up
- High chemical and physical homogeneity
- Transparent films, ideally for windows coatings

Sol



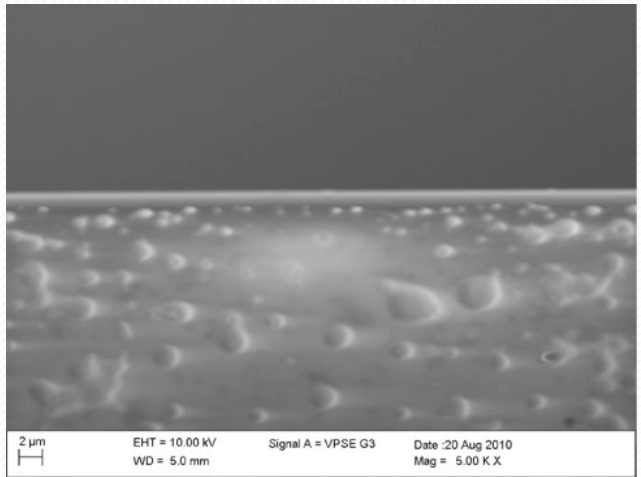
Precursors
Stabilizer
Catalysts

Gel



Hydrolysis
Condensation
Densification

Film



ZnO sol-gel stabilizers

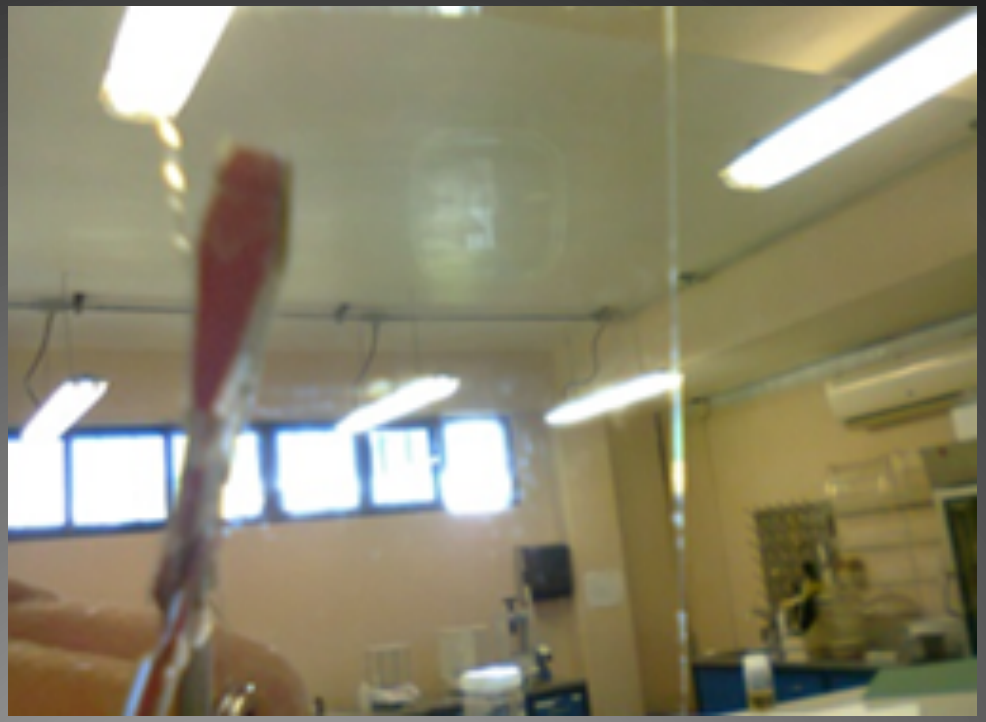
- Monoethanolamine
- Dimethylamine

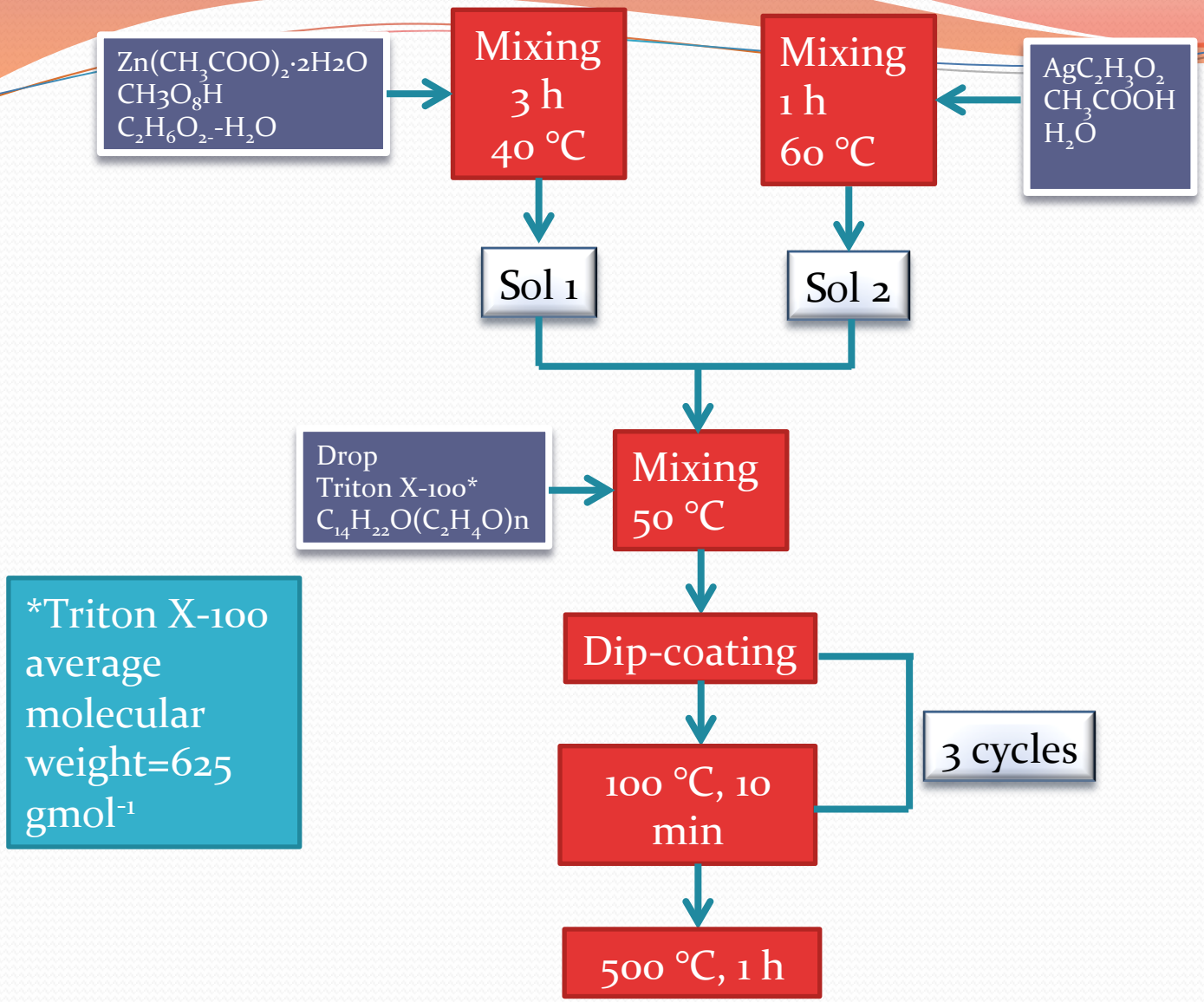
- Highly toxic 2-methoxyethanol as solvent

- New polymer stabilizers which also increases the thickness and reduces the cracks formations

- PVP
- F-127
- Triton X-100

Experimental Setup





*Triton X-100 average molecular weight=625 $gmol^{-1}$

Final appearance of sol-gel derived films

Results

FTIR

UV-Vis

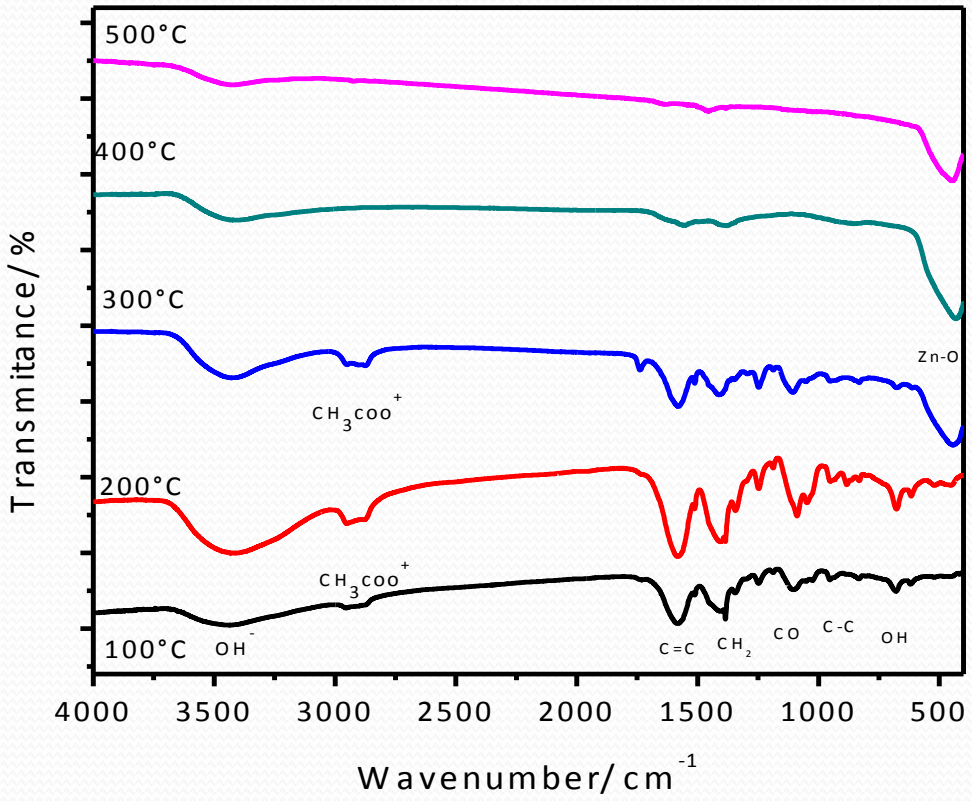
SEM

AFM

M-lines

Bacteriological study (*E. Colli*)

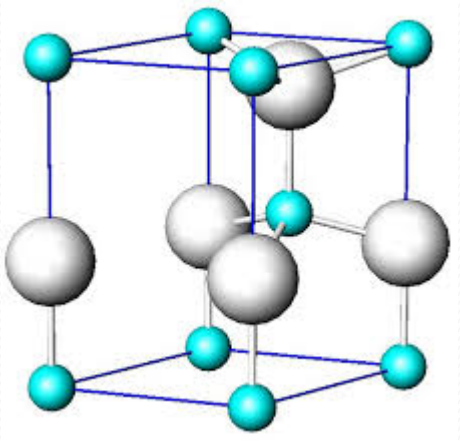
FTIR



Almost all the organics bands are eliminated from 400 °C, including the Triton X-100 C=C bands, indicating that at 500 °C only a ZnO product is expected.

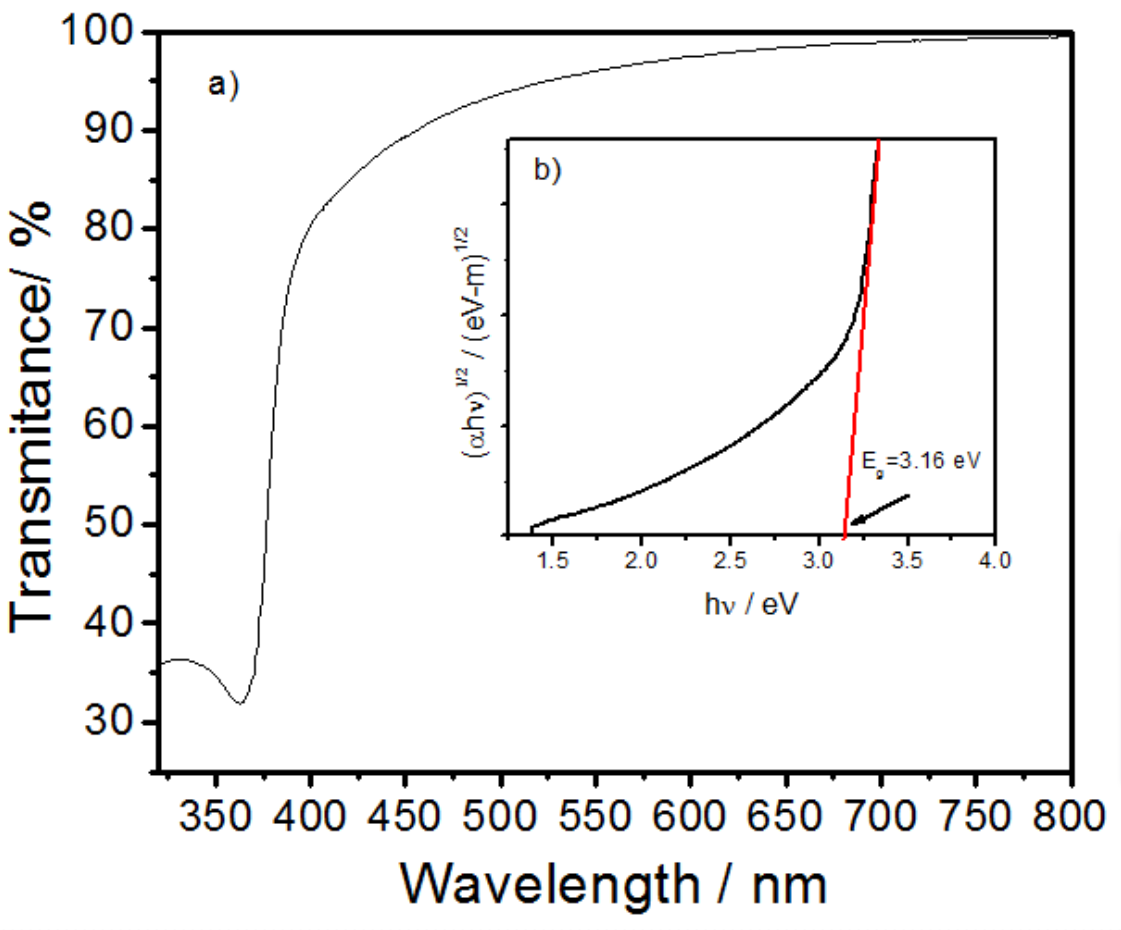
M lines

Ag content / mol %	Thickness / nm	Refractive index / a.u	Density / g cm^{-3}	Porosity /%
2.5	595	1.8695	5.12	15.5
5.0	612	1.8796	5.17	14.2



ZnO bulk properties
Density 5.60
Refractive index 1.9887

UV Vis

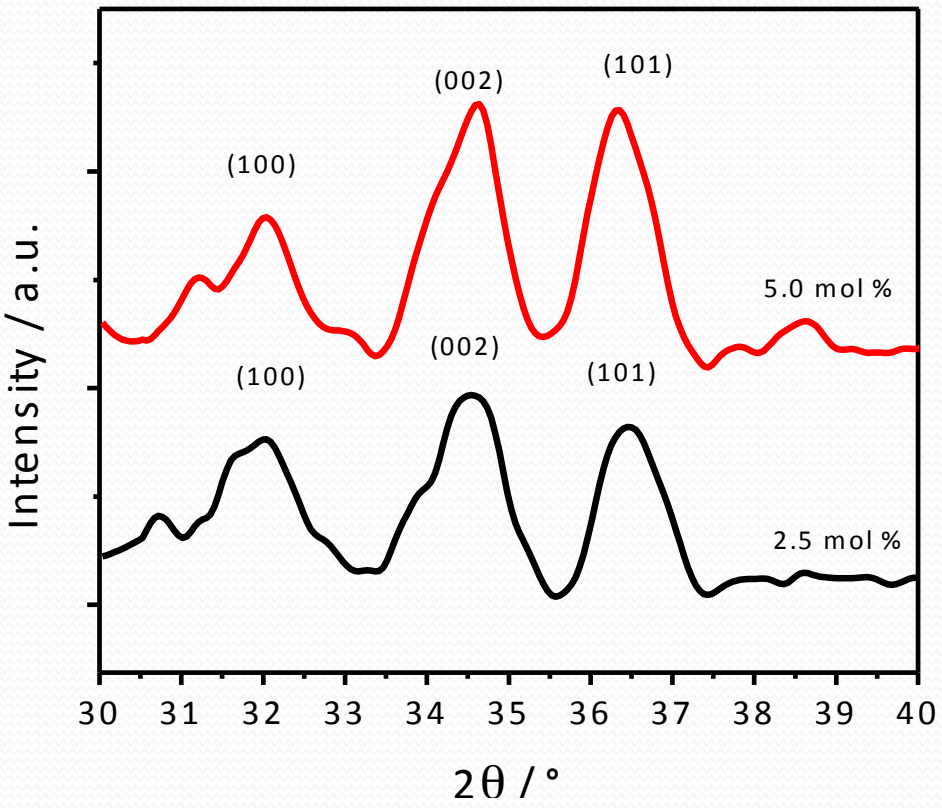


Transmittance higher than 80% within the visible region, with a sharp fundamental absorption edge at 380 nm

Calculated band gap: 3.16 eV (Tauc model)
Bulk bandgap: 3.20 eV

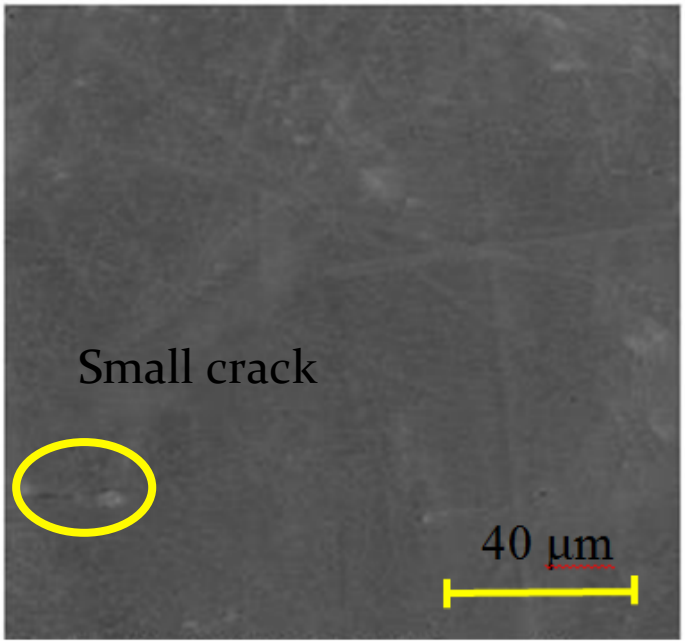
XRD

High crystallinity, corresponding to the ZnO wurtzite hexagonal structure (space group C6mc) with lattice parameters a = 3.2496 Å and c = 5.2065 Å, according to JCPDS Card No. 36-1451

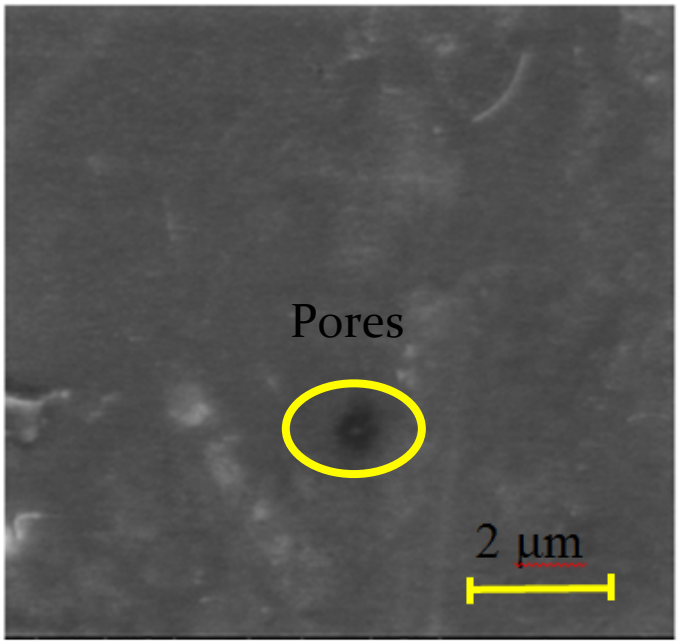


SEM

1000X

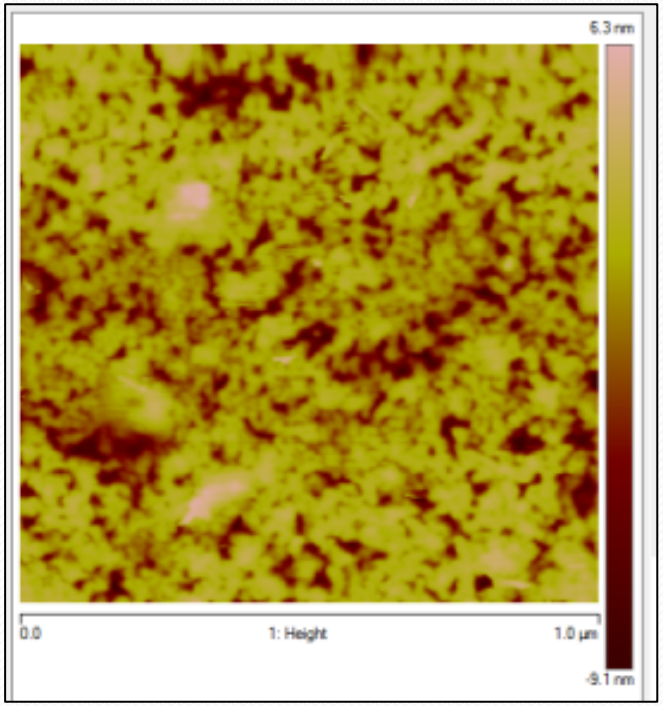


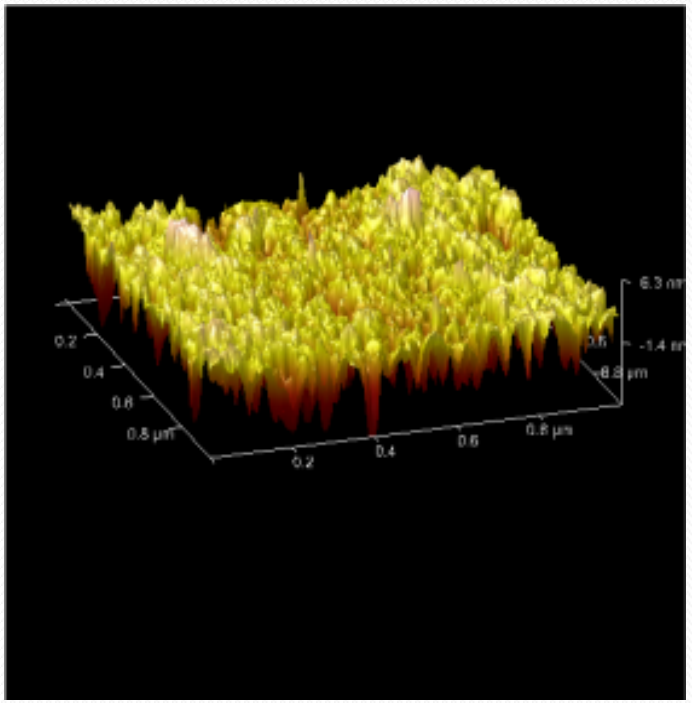
15,000 X



High physical homogeneity and the presence of small cracks which could reduce the antibacterial properties. The pore content is due to the leaving gases from the thermal decomposition of the sol during the annealing process. The CO_2 formed is product of the combustion of the organics compounds

AFM



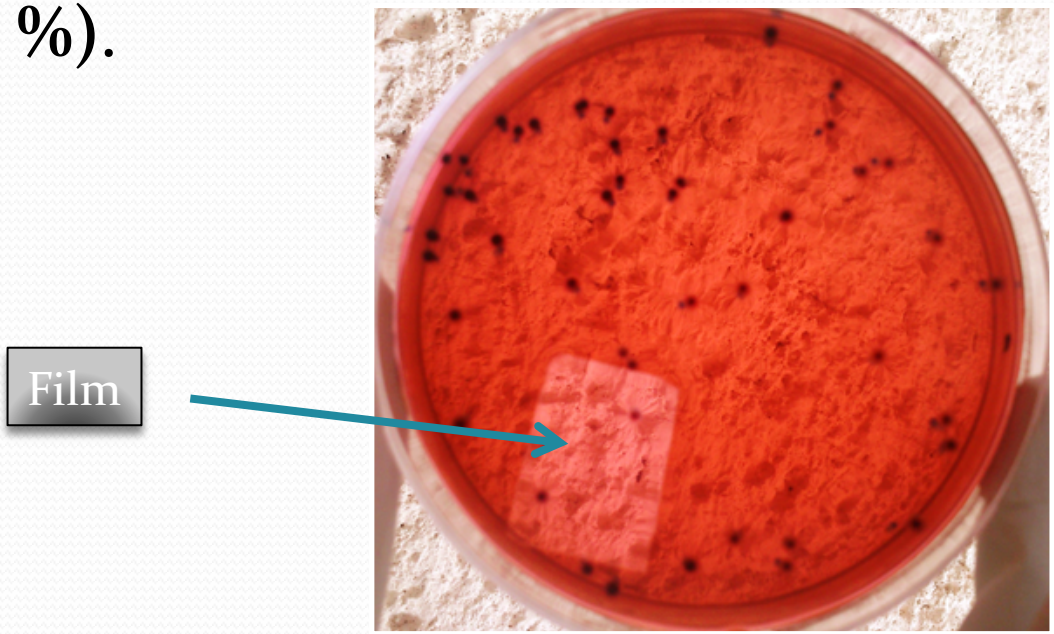


Very smooth surfaces (Ra=2.11 nm), of thin films formed of cross-linked particles of about ±20nm

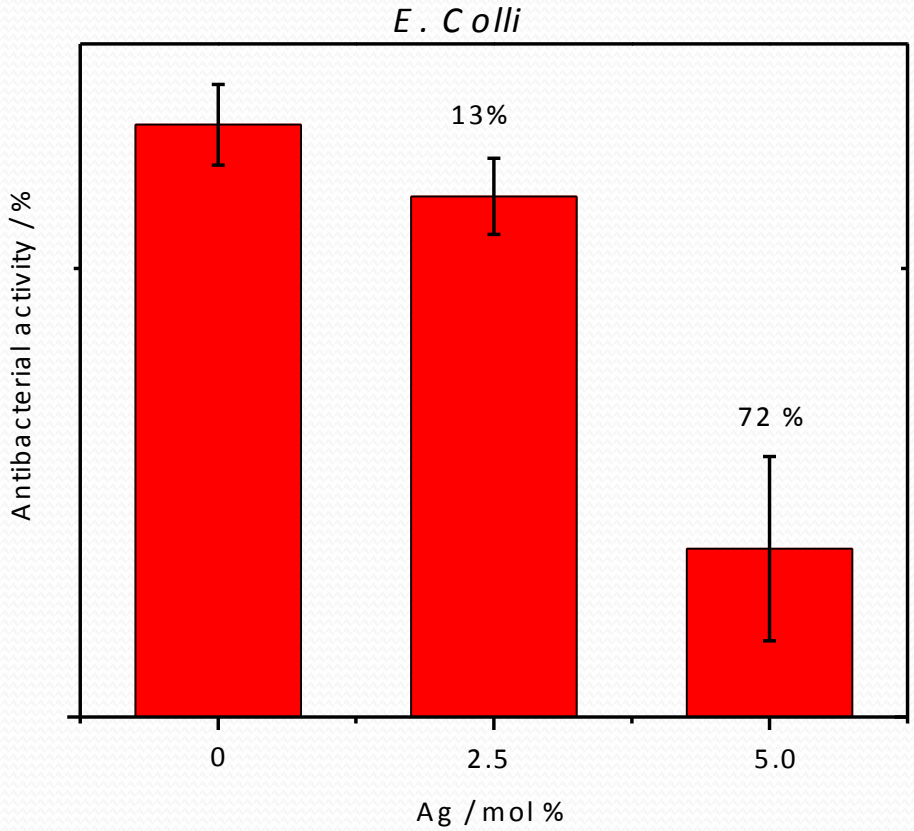
Conclusions

- The present work synthetized ZnO:Ag Triton X-100 modified thin films by a sol-gel process.
- The films with high **transparency, band gap=3.15** .15 eV.
- Hexagonal wurtzite structure from 500 °C.
- At 500 °C almost all the organic compounds are eliminated at this temperature.
- The morphology of the films homogeneous and almost crack-free, with the presence of residual pores probably product of the decomposition of the **organic** compounds.

- Finally, the antibacterial studies shown that for ***E. Coli*** bacteria, the higher microbicide effect is observed for the higher (5 mol %) Ag^{+} doped sample, 72 % compared with 13 % **at the lower sample (2.5 mol %)**.



Antibacterial effect



A clearly effect on the cell viability was observed compared with the control sample (at non-Ag content). The results show a decrease in the viability of the cells with respect to the control sample of 13 and 72 % for the 2.5 and 5.0 Ag^{2+} films, respectively

Acknowledgments

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