CENIMAT

VI Annual Meeting i3N, Lisboa 2017

Metal-oxide nanostructures synthesized under microwave irradiation

D. Nunes*, A. Pimentel, A. Rovisco, A. Gonçalves, A.C. Marques, S. Pereira, L. Santos, P. Barquinha, E. Fortunato* and R. Martins*

I3N/CENIMAT, Dep. de Ciência dos Materiais, Faculdade de Ciências e Tecnologia – Universidade NOVA de Lisboa and CEMOP-UNINOVA, 2829-516 Caparica, Portugal

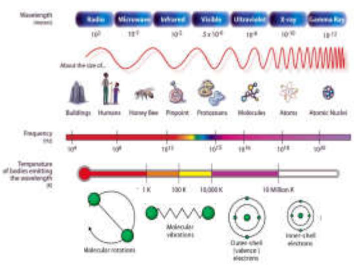
*corresponding author: daniela.gomes@fct.unl.pt; emf@fct.unl.pt; rm@uninova.pt

Introduction

The aim of environmentally friendly materials for multifunctional purposes and produced with low cost production routes is a reality nowadays. Chemical synthesis routes are known to be inexpensive and versatile, where the hydrothermal/solvothermal synthesis using conventional heating or more recently under microwave irradiation are interesting options for the production of high quality nanomaterials. Comparing conventional heating to microwave synthesis, the former is usually inefficient, time and energy consuming, while the latter has unique features such as short reaction time, enhanced reaction selectivity, energy saving, homogeneous volumetric heating and high reaction rate. In the present work, vanadium (VO_2), tungsten (WO_3), zinc (ZnO), zinc-tin (ZTO), copper (Cu_2O and CuO) and titanium (TiO_2) oxides were synthesized under microwave irradiation varying the synthesis parameters such as time, temperature, pressure, power input and solvent used. Several nanostructures such as spheres, stars, plates, whiskers, nanorods and nanowires were successfully synthesized [1,2], where these nanostructures were further structurally characterized by scanning electron microscopy (SEM) and employed in optoelectronic devices such as transistors, electrochromic and thermochromic devices, sensors, and as efficient photocatalysts.

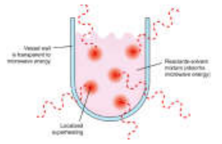
Microwave Synthesis

♦ Microwave (MW) is a form of electromagnetic radiation with wavelengths from 1 m to 1 mm, and frequencies between 300 MH and 300 GHz.

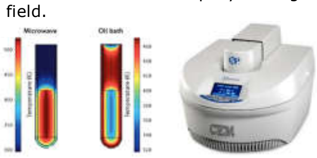


Heating by:

Dipole rotation: Polar molecules try to align themselves with the rapidly change of the MW electric field. This motion results in a transfer of energy.



Ionic conduction: the electric field generates ionic motion in free ions as the molecules try to align themselves to the rapidly change field.



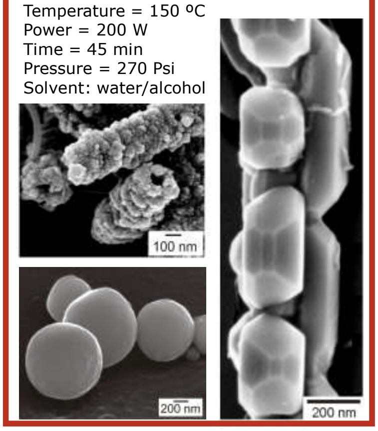
♦ Within this region only molecular rotation is affected, not molecular structure.

Power, time, pressure and temperature are the key parameters
Solvent influences the final materials

♦ **Microwave allows:**
- ✓ Selective heating
- ✓ High heating rates
- ✓ Short reaction time
- ✓ Improved reproducibility
- ✓ Pressure and temperature control

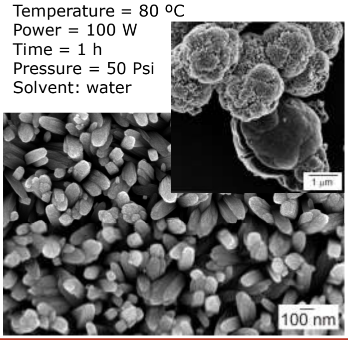
Cu_2O_CuO

Temperature = 150 ºC
Power = 200 W
Time = 45 min
Pressure = 270 Psi
Solvent: water/alcohol



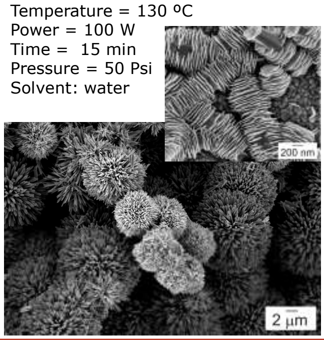
TiO_2

Temperature = 80 ºC
Power = 100 W
Time = 1 h
Pressure = 50 Psi
Solvent: water



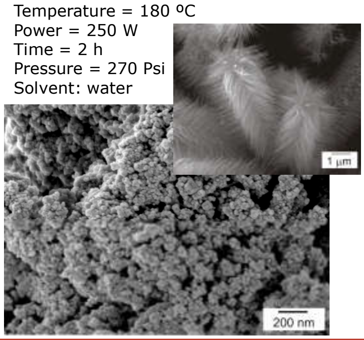
ZnO

Temperature = 130 ºC
Power = 100 W
Time = 15 min
Pressure = 50 Psi
Solvent: water



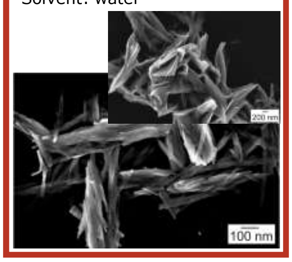
ZTO (Zn_2SnO_4)

Temperature = 180 ºC
Power = 250 W
Time = 2 h
Pressure = 270 Psi
Solvent: water



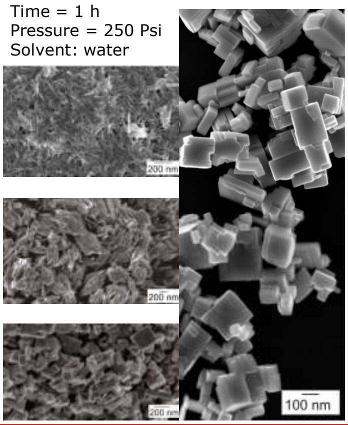
VO_2

Temperature = 160 ºC
Power = 250 W
Time = 20 min
Pressure = 250 Psi
Solvent: water

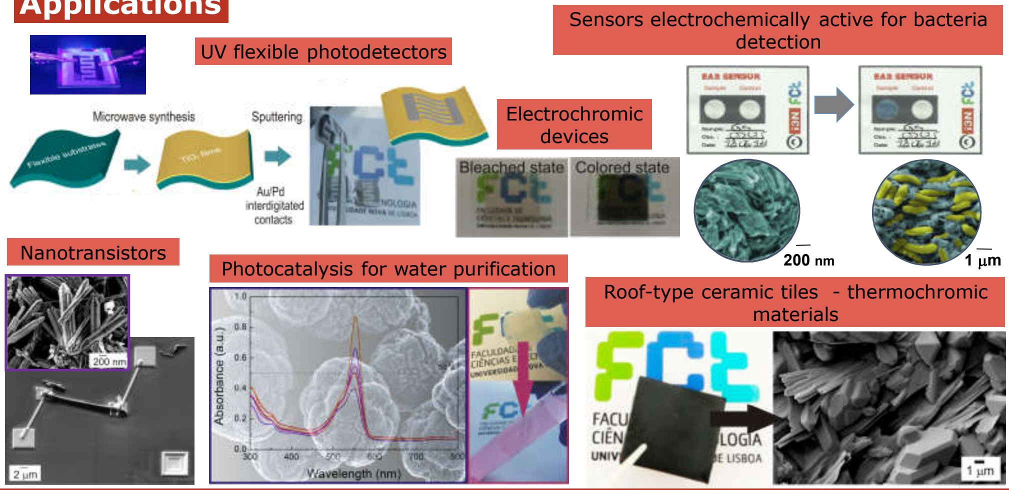


WO_3

Temperature = 180 ºC
Power = 150 W
Time = 1 h
Pressure = 250 Psi
Solvent: water



Applications



References

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[2] Nunes D., Pimentel A., Pinto J.V., Calmeiro T.R., Nandy S., Barquinha P., Pereira L., Carvalho P.A., Fortunato E., Martins R., Photocatalytic behavior of TiO_2 films synthesized by microwave irradiation, *Catalysis Today* 278 (2016) 262–270.

Acknowledgments

This work is funded by National Funds through FCT - Portuguese Foundation for Science and Technology, Reference UID/CTM/50025/2013 and FEDER funds through the COMPETE 2020 Programme under the project number POCI-01-0145-FEDER-007688.

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