University of Belgrade, Technical Faculty in Bor

30th International Conference Ecological Truth & Environmental Research

2023

Proceedings

Editor
Prof. Dr Snežana Šerbula

PROCEEDINGS

30^{th} INTERNATIONAL CONFERENCE

ECOLOGICAL TRUTH AND ENVIRONMENTAL RESEARCH – EcoTER’23

Editor:
Prof. Dr Snežana Šerbula
University of Belgrade, Technical Faculty in Bor
Editor of Student section:
Prof. Dr Maja Nujkić
University of Belgrade, Technical Faculty in Bor

Technical editors:
Jelena Milosavljević, PhD, University of Belgrade, Technical Faculty in Bor
Asst. prof. Dr Ana Radojević, University of Belgrade, Technical Faculty in Bor
Sonja Stanković, **MSc**, University of Belgrade, Technical Faculty in Bor

Cover design:
Aleksandar Cvetković, **BSc**, University of Belgrade, Technical Faculty in Bor

Publisher: University of Belgrade, Technical Faculty in Bor

For the publisher: Prof. Dr Dejan Tanikić, Dean

Printed: University of Belgrade, Technical Faculty in Bor, 100 copies, electronic edition

Year of publication: 2023

ISBN 978-86-6305-137-9

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

502/504(082)(0.034.2)
574(082)(0.034.2)

INTERNATIONAL Conference Ecological Truth & Environmental Research (30 ; 2023)
Proceedings [Elektronski izvor] / 30th International Conference Ecological Truth & Environmental Research - EcoTER'23, 20-23 June 2023, Serbia ; organized by University of Belgrade, Technical faculty in Bor (Serbia) ; co-organizers University of Banja Luka, Faculty of Technology – Banja Luka (B&H) ... [et al.] ; [editor Snežana Šerbula]. - Bor : University of Belgrade, Technical faculty, 2023 (Bor : University of Belgrade, Technical faculty). - 1 elektronski optički disk (CD-ROM) ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Preface / Snežana Šerbula. - Tiraž 100. - Bibliografija uz svaki rad.

ISBN 978-86-6305-137-9

а) Животна средина -- Зборници б) Екологија – Зборници

COBISS.SR-ID 118723849

30th International Conference
Ecological Truth and Environmental Research – EcoTER’23

is organized by:

UNIVERSITY OF BELGRADE
TECHNICAL FACULTY IN BOR (SERBIA)

Co-organizers of the Conference:

University of Banja Luka, Faculty of Technology,
Banja Luka (B&H)

University of Montenegro, Faculty of Metallurgy and Technology,
Podgorica (Montenegro)

University of Zagreb, Faculty of Metallurgy, Sisak (Croatia)

University of Pristina, Faculty of Technical Sciences,
Kosovska Mitrovica

Association of Young Researchers Bor (Serbia)

HONORARY COMMITTEE

SCIENTIFIC COMMITTEE

Prof. Dr Snežana Šerbula, *President*

Prof. Dr Alok Mittal
(India)
Prof. Dr Jan Bogaert
(Belgium)
Prof. Dr Aleksandra Nadgórska-Socha
(Poland)
Prof. Dr Luis A. Cisternas
(Chile)
Prof. Dr Wenhong Fan
(China)
Prof. Dr Martin Brtnický
(Czech Republic)
Prof. Dr Isabel M. De Oliveira Abrantes
(Portugal)
Prof. Dr Shengguo Xue
(China)
Prof. Dr Tomáš Lošák
(Czech Republic)
Prof. Dr Maurice Millet
(France)
Prof. Dr Murray T. Brown
(New Zealand)
Prof. Dr Xiaosan Luo
(China)
Prof. Dr Daniel J. Bain
(United States of America)
Prof. Dr Che Fauziah Binti Ishak
(Malaysia)
Prof. Dr Richard Thornton Baker
(United Kingdom)
Prof. Dr Mohamed Damak
(Tunisia)
Prof. Dr Jyoti Mittal
(India)
Prof. Dr Miriam Balaban
(United States of America)

Prof. Dr Yeomin Yoon
(United States of America)
Prof. Dr Chang-min Park
(South Korea)
Prof. Dr Faramarz Doulati Ardejani
(Iran)
Prof. Dr Ladislav Lazić
(Croatia)
Prof. Dr Natalija Dolić
(Croatia)
Prof. Dr Milutin Milosavljević
(Kosovska Mitrovica)
Prof. Dr Nenad Stavretović
(Serbia)
Prof. Dr Ivan Mihajlović
(Serbia)
Prof. Dr Milovan Vuković
(Serbia)
Prof. Dr Nada Blagojević
(Montenegro)
Prof. Dr Darko Vuksanović
(Montenegro)
Prof. Dr Irena Nikolić
(Montenegro)
Prof. Dr Šefket Goletić
(B&H)
Prof. Dr Džafer Dautbegović
(B&H)
Prof. Dr Borislav Malinović
(B&H)
Prof. Dr Slavica Sladojević
(B&H)
Prof. Dr Nada Šumatić
(B&H)
Prof. Dr Snežana Milić
(Serbia)

Prof. Dr Fernando Carrillo-Navarrete
(Spain)
Prof. Dr Pablo L. Higueras
(Spain)
Prof. Dr Mustafa Cetin
(Turkey)
Prof. Dr Mauro Masiol
(Italy)
Prof. Dr George Z. Kyzas
(Greece)
Prof. Dr Mustafa Imamoğlu
(Turkey)
Prof. Dr Petr Solzhenkin
(Russia)

Prof. Dr Dejan Tanikić
(Serbia)
Prof. Dr Milan Trumić
(Serbia)
Dr Jasmina Stevanović
(Serbia)
Dr Dragana Ranđelović
(Serbia)
Dr Viša Tasić
(Serbia)
Dr Ljiljana Avramović
(Serbia)
Dr Stefan Đorđievski
(Serbia)

ORGANIZING COMMITTEE

Prof. Dr Snežana Šerbula, *President*

Prof. Dr Snežana Milić, *Vice President*

Prof. Dr Đorđe Nikolić, *Vice President*

Prof. Dr Marija Petrović Mihajlović

Prof. Dr Milan Radovanović

Prof. Dr Milica Veličković

Prof. Dr Danijela Voza

Prof. Dr Maja Nujkić

Prof. Dr Žaklina Tasić

Dr Ana Simonović

Dr Tanja Kalinović

Dr Ana Radojević

Dr Jelena Kalinović

Dr Jelena Milosavljević

Sonja Stanković, MSc

Miljan Marković, MSc

Vladan Nedelkovski, MSc

Aleksandar Cvetković, BSc

OPTICALLY ACTIVE NANOMATERIALS FOR ENVIRONMENTAL REMEDIATION

Lidija Mančić[1*], Maria Eugenia Rabanal[2], Bojan Marinkovic[3]
[1]Institute of Technical Sciences of SASA, Belgrade, SERBIA
[2]University Carlos III, Madrid, SPAIN
[3]Pontifical Catholic University of Rio de Janeiro, RJ, BRAZIL
[*]*lidija.mancic@itn.sanu.ac.rs*

Abstract

In recent years optically active nanomaterials have opened up a number of frontiers, especially in life science and environmental protection. Novel hybrid nanomaterials based on wide band gap oxides (TiO_2) *and* Ln^{3+} *doped rare earth compounds (down- and up-conversion luminescence materials) obtained through innovative processing will be presented from the viewpoint of their potential application for light harvesting and photocatalysis.*

Keywords: luminescence, up-conversion, core-shell, charge-transfer complex, photocatalysis.

INTRODUCTION

The field of nanoscience has made exciting progress in recent decades, particularly regarding the synthesis of optically active nanoparticles that might be able to solve some of the aroused energy and environmental problems. One of the key points in achieving a sustainable low carbon society is development of innovative synthesis routes which could ensure processing of nanomaterials in a controlled manner. The synthesis from solution, such as spray pyrolysis and hydro/solvo-thermal processing, offers many advantages over conventional solid-state synthesis: design of nanomaterials at the molecular level, tuning of their crystallinity, control of morphology and homogeneous doping. While spray pyrolysis comprises formation and decomposition of aerosol in a high temperature tubular flow reactor, hydro/solvothermal processing refers to any homogeneous or heterogeneous reaction in the presence of aqueous or organic solvents at elevated pressure and temperature in a closed vessel. Both methods are successfully developed in the scope of research activities in the Institute of Technical Sciences of SASA [1,2]. The examples from some wide band gap oxides and down- and up-conversion luminescence materials processed using these, will be presented and discussed from the viewpoint of their potential use for environmental remediation.

MATERIALS AND METHODS

YAG:Ce, $Y_{1-x}Gd_xO_3$:Eu, Y_2O_3:Yb and $NaY_{1-x}Gd_xF_4$:Yb co-doped with Er, Tm or Ho, YF_3:Yb,Er, hybrid TiO_2 and TiO_2-based nanoparticles, as well as, Y_2O_3:Eu@Ag and

$NaYF_4$:Yb,Tm@TiO_2-Acac core-shell structures, were synthesised in accordance to the previously published procedures [1–10].

RESULTS AND DISCUSSION

Figure 1 presents typical morphologies of nanoparticles obtained through spray pyrolysis in function of precursor type. The diverse levels of structural, morphological and functional complexity are achieved by appropriate setting of processing parameters, i.e. temperature (which controls volume/surface precipitation in droplets and phase composition) and precursor concentration (which affects particle size and agglomeration degree).

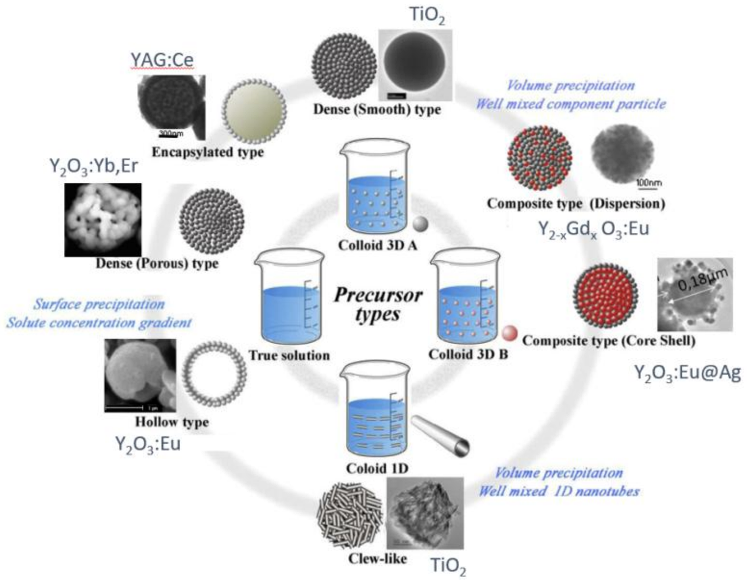

Figure 1 *Morphologies of nanoparticles obtained through spray pyrolysis*

Figure 2 presents typical morphologies of nanoparticles obtained through hydro/solvo-thermal processing. Their structural properties are defined by the main processing parameters, i.e., temperature, pressure, time, pH and precursor/solvent type, while their surface chemistry is tailored by the addition of surfactants (EDTA, PEG, PVP, PLGA, Chitosan).

Both methods belong to the bottom-up building blocks synthesis approach, which enables enhancing a specific functionality through the synergy of properties associated with different structural levels and interactions at their interfaces. As a result, such particles could be used in displays, lighting, photovoltaics and photocatalysis. For lighting application in small devices, besides being used as white emission mercury-free sources, nanophosphors need to have broad range tunability of a multi-colour emission by single wavelength excitation which could be achieved through co-doping. Tuneable absorption in the infrared spectrum and ability to convert a low-energy infrared radiation into high-energy emission, make them attractive for infrared-driven photocatalysis and light harvesting improvement in the state-of-the-art solar cells. This is because the spectral distribution of sunlight at air mass 1.5 Global includes photons with a wide range of wavelengths, ranging from 280 to 2500 nm (0.5–4.4 eV), while the current generation of photocatalysts and solar cells utilize only a small fraction of the incident photons which energy match their energy bandgap.

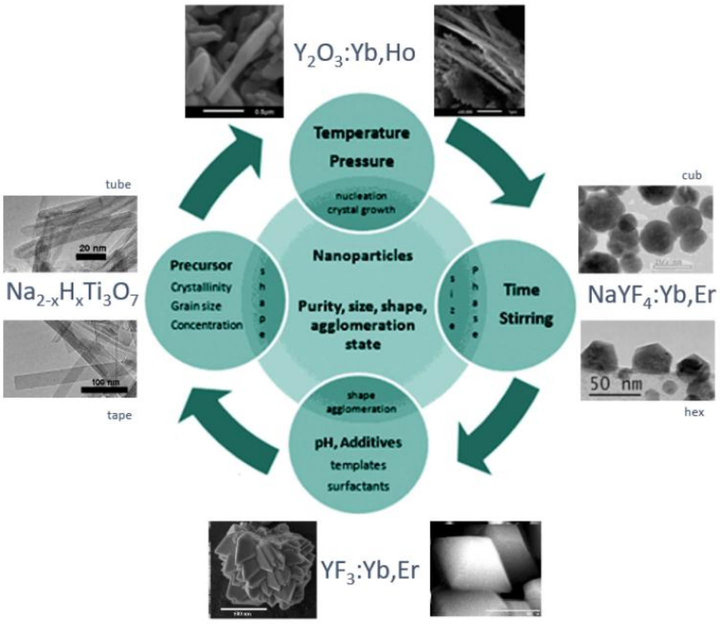

Figure 2 *Morphologies of nanoparticles obtained through hydro/solvo-thermal processing*

Recently we shown that efficiency of the novel hybrid core-shell structure, in which up-converting core $NaYF_4$:Yb,Tm acts as a medium for converting NIR to visible light via multiphoton up-conversion processes while TiO_2-Acetylacetonate shell absorbs the visible light through direct injection of excited electrons from the highest-occupied-molecular-orbital (HOMO) of Acetylacetonate into the TiO_2 conduction band (CB), toward tetracycline degradation is twofold better that of TiO_2-Acetylacetonate solely.

CONCLUSION

The essential principles for rational design of efficient optically active materials were highlighted. Particular emphasis is placed on synthesis methods developed in the Institute of Technical Sciences of Serbia, as well as on hybrid structure materials for future development of infrared-driven photocatalysts and photovoltaics.

ACKNOWLEDGEMENT

The corresponding author is grateful to the Ministry of Science, Technological Development and Innovation of Republic of Serbia for financial support according to the contract with the registration number (451-03-47/2023-01/200175) and Science Fund of the Republic of Serbia (program DIJASPORA, #6421090, COSH-PHOTO).

REFERENCES

[1] Milosevic O., Mancic L., Rabanal M. E., *et al.*, Powder Part. J. 27 (2009) 84–106.

[2] Mancic L., Nikolic M., Gomez L., *et al*., Adv. Powder Technol. 28 (2017) 3–22.

[3] Dugandžić I., Jovanović D. J., Mančić L., *et al*., J. Nanoparticle Res. 14 (2012) 1157.

[4] Mancic L., Marinkovic K., Marinkovic B.A., *et al*., J. Eur. Ceram. 30 (2010) 577–582.

[5] Alkan G., Mancic L., Tamura S., *et al*., Adv. Powder Technol. 30 (2019) 1409–1418.

[6] Mancic L., Marinkovic B. A., Jardim P. M., *et al*., Cryst. Growth Des. 9 (2009) 2152–2158.

[7] Habran M., Ponton P. I., Mancic L., *et al*., J. Photochem. Photobiol. A 365 (2018) 133–144.

[8] Dinic I. Z. Mancic L. T., Rabanal M. E., *et al*., Adv. Powder Technol. 28 (2017) 73–82.

[9] Mancic L., Lojpur V., Marinkovic B., *et al*., Adv. Powder Technol. 25 (2014) 1449–1454.

[10] Marković S., Machado T. M., Dinić I., *et al*., Proceedings of the 15th International Conference on Fundamental and Applied Aspects of Physical Chemistry Vol II, on-line (2021) 399–401.