chemistry proceedings

MDPI

Abstract

Hybrid Materials Based on Multi-Walled Carbon Nanotubes and TiO_2 Nanoparticles with Antimicrobial Properties †

Madalina Elena David [1,2,*], Rodica Mariana Ion [1,2], Lorena Iancu [1], Ramona Marina Grigorescu [1], Alina Maria Holban [3], Raluca Somoghi [1], Adrian Ionut Nicoara [4], Bogdan Spurcaciu [1] and Anca Irina Gheboianu [5]

1 National Institute for Research and Development in Chemistry and Petrochemistry—ICECHIM, 060021 Bucharest, Romania; rodica.ion@icechim.ro (R.M.I.); lorena.iancu@icechim.ro (L.I.); ramona.grigorescu@icechim.ro (R.M.G.); raluca.somoghi@icechim.ro (R.S.); bogdan.spurcaciu@icechim.ro (B.S.)
2 Doctoral School of Materials Engineering Department, Valahia University of Targoviste, 130004 Targoviste, Romania
3 Faculty of Biology, University of Bucharest, 060101 Bucharest, Romania; alina.m.holban@bio.unibuc.ro
4 Faculty of Applied Chemistry and Materials Science, University Politehnica of Bucharest, 011061 Bucharest, Romania; adrian.nicoara@upb.ro
5 Institute of Multidisciplinary Research for Science and Technology, Valahia University of Targoviste, 130004 Targoviste, Romania; anca@icstm.ro
* Correspondence: madalina.david@icechim.ro
† Presented at the 17th International Symposium "Priorities of Chemistry for a Sustainable Development" PRIOCHEM, Bucharest, Romania, 27–29 October 2021.

Keywords: hybrid materials; decorated nanotubes; nanoparticles; antimicrobial properties

Citation: David, M.E.; Ion, R.M.; Iancu, L.; Grigorescu, R.M.; Holban, A.M.; Somoghi, R.; Nicoara, A.I.; Spurcaciu, B.; Gheboianu, A.I. Hybrid Materials Based on Multi-Walled Carbon Nanotubes and TiO_2 Nanoparticles with Antimicrobial Properties. *Chem. Proc.* **2022**, *7*, 64. https://doi.org/10.3390/chemproc2022007064

Academic Editors: Mihaela Doni, Florin Oancea, Zina Vuluga and Radu Claudiu Fierăscu

Published: 13 April 2022

Worldwide, one of the most significant threats to human health problems remains antibiotic resistance. In the last several years, bacteria have evolved in order to survive antimicrobial treatments by effectively developing resistance mechanisms [1]. It has been shown that nanoparticles and nanotubes have outstanding antimicrobial activity due to the increased contact area with bacteria [2]. The aim of this study was to design and characterize hybrid materials composed by multi-walled carbon nanotubes (MWCNTs) decorated with TiO_2 nanoparticles, in order to obtain an efficient nanosystem with improved antimicrobial activity by a fast and low-cost method. The carbon nanotubes used in this study were obtained by chemical synthesis [3] and used as a template for TiO_2 nanoparticles formation. The nanocomposites (MWCNTs_TiO_2) were obtained by TiO_2 in situ attachment on the surface of MWCNTs, by using a titanium (IV) isopropoxide precursor. The obtained hybrid nanomaterials were further characterized by Raman Spectroscopy Analysis, X-ray Diffraction Analysis (XRD), and Transmission Electron Microscopy (TEM). The antimicrobial activity of MWCNTs_TiO_2 was investigated against two Gram-positive (*Staphylococcus aureus*, *Bacillus subtilis*), two Gram-negative (*Pseudomonas aeruginosa*, *Escherichia coli*) and one yeast (*Candida albicans*) to cover the most important model opportunistic pathogens. TEM micrographs revealed that the MWCNTs have a diameter between 9 and 50 nm and a length of 600 nm and TiO_2 nanoparticles with a diameter of about 15 nm were successful deposited on the nanotubes surface. Qualitative testing of antimicrobial activity demonstrated that MWCNT_TiO_2 were able to inhibit growth for all tested strains, mostly in the case of the Gram-negative bacteria (*E. coli* and *P. aeruginosa*). Quantitative tests showed that the obtained nanocomposites have more pronounced antimicrobial effects on Gram-negative bacteria compared to the yeast or Gram-positive bacteria. This can be explained with the particularities of the cellular wall of each type of bacteria, Gram-negative bacteria have a thin peptidoglycan layer and an outer lipid membrane, which make the bacteria easier to inhibit and leads to a faster destructibility of the cell membrane. The decoration

of MWCNTs with TiO_2 nanoparticles has been successful carry out, spherical nanoparticles with a diameter about 15 nm being attached to the nanotubes surface. The obtained nanocomposites presented more pronounced antimicrobial activity on Gram-negative bacteria. The obtained results sustained that the synthetized nanocomposites can be considered as competitive candidates for the development of efficient antimicrobial systems (Figure 1).

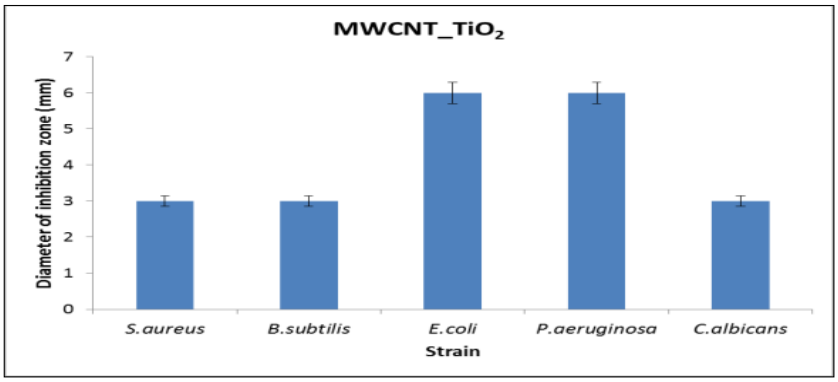

Figure 1. Diameter of inhibition zone for the obtained nanocomposite.

Funding: This work was supported by a grant of the Romanian Ministry of Research and Innovation, CCCDI—UEFISCDI, project number PN-III-P1-1.2-PCCDI-2017-0476/51PCCDI/2018, within PNCDI III and PN.19.23.03.01 contract no. 23N/2019 within the NUCLEU Program.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Grigore, M.E.; Grumezescu, A.M.; Holban, A.M.; Mogoşanu, G.D.; Andronescu, E. Collagen-nanoparticles composites for wound healing and infection control. *Metals* **2017**, *7*, 516. [CrossRef]
2. David, M.; Ion, R.-M.; Grigorescu, R.M.; Iancu, L.; Holban, A.; Nicoara, A.; Alexandrescu, E.; Somoghi, R.; Ganciarov, M.; Vasilievici, G.; et al. Hybrid Materials Based on Multi-Walled Carbon Nanotubes and Nanoparticles with Antimicrobial Properties. *Nanomaterials* **2021**, *11*, 1415. [CrossRef] [PubMed]
3. David, M.E.; Grigorescu, R.M.; Iancu, L.; Andrei, E.R.; Somoghi, R.; Frone, A.N.; Atkinson, I.; Predoana, L.; Nicoara, A.-I.; Ion, R.-M. Synthesis and characterization of multi-walled carbon nanotubes decorated with hydroxyapatite. *Full-Nanotub. Carbon Nanostruct.* **2021**, *29*, 423–430. [CrossRef]