RĂSPUNSUL CELULELOR DE ESCHERICHIA COLI LA ACȚIUNEA MATERIALELOR PE BAZĂ DE ZnSe
THE RESPONSE OF ESCHERICHIA COLI CELLS TO THE ACTION OF ZnSe BASED MATERIALS

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This study was undertaken as an attempt to assess the effects of ZnSe based materials toward Escherichia coli cells. ZnSe materials with spherical and flower-like morphologies were obtained in hydrothermal conditions. Qualitative and quantitative assays were conducted to evaluate the antibacterial activity. The effect of materials on the bacterial cells was observed by electron microscopy. Repetitive Sequence-Based PCR (rep-PCR) and polymerase chain reaction (PCR) of the 16S rRNA gene analyses were performed after the interaction of the samples with the bacterial cells. The results demonstrate that the antibacterial activity was influenced by concentration, size, time exposure, and shape of the material. Thus, ZnSe with flower-like morphology exhibited higher antibacterial activity on Escherichia coli reference strain compared with the micro-sized ZnSe spheres, related to their different morphology and their higher surface area

Acest studiu a fost realizat pentru a evalua efectele materialelor pe bază de ZnSe asupra celulelor de Escherichia coli. Materialele de ZnSe cu morfologie sferică și tip floare au fost obținute în condiții hidrotermale. Analize calitative și cantitative au fost efectuate pentru a evalua activitatea antibacteriană. Efectul materialelor asupra celulelor bacteriene a fost observat prin microscopie electronică. Au fost efectuate analize rep-PCR (reacția de polimerizare în lanț pe bază de secvențe repetitive) și 16S rRNA (amplificarea prin tehnica de polimerizare în lanț a genei pentru ARNr 16S) după interacțiunea probelor cu celulele bacteriene. Rezultatele demonstrează că activitatea antibacteriană a fost influențată de concentrația, dimensiunea, timpul de expunere și forma materialului. Astfel, materialele de ZnSe cu morfologie tip floare au prezentat o activitate antibacteriană mai mare asupra tulpinii de referință Escherichia coli comparativ cu microsferele de ZnSe, corelată cu morfologia lor diferită și cu suprafața specifică mai ridicată.

Keywords: *zinc selenide, antibacterial activity, Escherichia coli*

1. Introduction

Nowadays, nanotechnology proves to be an interdisciplinary field, integrating engineering with chemistry, biology, physics, and medicine [1-9]. If the physical and chemical properties of nanoparticles were studied several years ago, research is currently investigated for transferring the results of nano/bio research to the productive area [10].

Nanomaterials have become part of our lives, as constituents of many consumer products such as cosmetics and personal care merchandise, paint pigments, food, paper, pharmaceuticals, biosensors, etc. [11], and their effect on environment and living beings has attracted the attention of many researchers, which has led to a continuously increasing number of studies in this research area [12-16].

Nanoscale ranged materials emphasize unusual and unexpected properties due to their high exposed surface area, more promising in terms of chemical and biological reactivity than the bulk ones (macroscopic). In this sense, some nanoparticles have demonstrated their antibacterial activity, acting on both Gram-positive and Gram-negative bacteria. For example, copper oxide (CuO), nickel oxide (NiO), zinc oxide (ZnO), antimony trioxide (Sb_2O_3) nanoparticles were found to have a toxic effect on *Escherichia coli*, *Bacillus subtilis* and *Staphylococcus aureus* bacterial strains [17]. Ramalingam et al. [18] reported that silver nanoparticles (Ag NP_s) exert concentration-dependent antibacterial activity against *Escherichia coli* and *Pseudomonas aeruginosa.* Nanoscale titanium dioxide (TiO_2) is one of the most investigated photocatalytic semiconductors, and its bactericidal effect on a wide spectrum of pathogenic bacteria has been demonstrated [19]. Nanomaterials with antibacterial properties (i.e., metal, metal oxide, organic nanoparticles) exhibit a diversity of intrinsic and modified chemical composition properties leading to their different action modes [20]. Among the most important variables that influence the antibacterial activity of materials are as follows: chemistry, particle size, particle shape, and zeta potential [21]. However, the action mechanism of nanoparticles is still poorly understood. Numerous studies have considered that the generation of reactive oxygen species is

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the main factor responsible for the antimicrobial properties of various nanoparticles [21, 22]. Non-oxidative mechanisms [23] or metal ion release [24] are also frequently proposed and accepted in current research.

This study was carried out to examine the growth of *Escherichia coli* ATCC 25922 reference strain in the presence of synthesized zinc selenide (ZnSe) based materials. ZnSe, one of the important Zn-based II-VI semiconductors, has wide-ranging application in laser, optical instruments, or nanosensors [25]. Few attempts have been made to investigate the antibacterial properties of ZnSe micro- and nanomaterials [26-28].

2. Experimental

2.1 Synthesis methods

ZnSe based materials having both spherical and flower-like morphology were obtained in hydrothermal conditions at 120°C by using sodium selenite (0.172g anhydrous Na_2SeO_3, 99% min, Alfa Aesar) and 0.29g zinc sulfate heptahydrate (99.5%, Roth). Hydrazine monohydrate ($N_2H_4 \cdot H_2O$ 98%, Alfa Aesar) was used as a reducing agent. The pH of the reaction mixture was controlled with an aqueous solution of NaOH (Alfa Aesar) (ultrapure water, Millie-Q system >18MΩcm). Depending on the pH and of the time of reaction, spheres, or flower type structures resulted. Accordingly, using a pH lower than 11 and 3 hours of thermal treatment spheres were obtaining, while by increasing pH and reaction time (5 hours), flower type morphology can be obtained. The as-synthesized ZnSe based materials were recovered after filtration, washing with ultrapure water and drying at 60^0C in airflow.

2.2 Characterization of the ZnSe nanomaterials

2.2.1. Scanning electron micrographs (SEM) were recorded with a high-resolution microscope, FEI Quanta 3D FEG model, using a 5 kV voltage and an Everhart–Thornley secondary electron (SE) detector.

2.2.2. X-ray diffraction (XRD) data *were* achieved by using a Rigaku diffractometer type Ultima IV, with a Cu tube (k = 0.15418 nm) operating at 40 kV and 30 mA. For phase identification, a Rigaku's PDXL software was used in connection to the ICDD database.

2.2.3. Nitrogen sorption measurements were done using a Micromeritics ASAP 2020 automated gas sorption system, at -196°C, Brunauer-Emmett-Teller (BET) surface area analysis (S_{BET}) being performed. The pore size distribution curves were obtained from the desorption branch data in addition to the Barrett–Joyner–Halenda (BJH) method.

2.2.4. Zeta potential measurements were carried out on a Malvern Nano ZS Zetasizer (ZEN 3600), at room temperature and aqueous media.

2.3 Bacterial strains, media and growth conditions

Gram-negative bacterium *Escherichia coli* ATCC 25922 was selected for antibacterial tests. The bacterial cells were grown from frozen glycerol stock on Luria-Bertani (LB) broth and incubated overnight at 37°C with shaking. Luria-Bertani (LB) liquid culture medium had the following composition (g/L): tryptone 10, yeast extract 5, sodium chloride, 10.

2.4 Antibacterial activity experiments

The assessment of bacterial growth in the presence of ZnSe based materials was accomplished by using the direct method, which implies the determination of the viable cells number by the pour plate method. To conduct the tests, LB liquid culture medium was inoculated, starting from a liquid bacterial culture grown overnight from frozen glycerol stock, then the suspension was adjusted to an initial optical density of 0.15 OD at 660 nm (OD_{660nm}) and treated with different concentrations of synthesized zinc selenide materials. The total working volume for each test variant was 10 mL. The material concentrations used for the experiments were 0.05 mg/mL and 0.5 mg/mL. The bacterial cells were exposed to materials in LB culture medium for 4, 6, and 24 hours on a shaker incubator (150 rpm) at 37°C. A control sample was also prepared, being represented by the untreated bacterial culture. The number of surviving bacteria was counted on agar plates after 24 hours of incubation at 37°C and was expressed as colony-forming units per milliliter (CFU/mL). The percentage of bacterial reduction was calculated.

The cellular viability was also evaluated by determining the dehydrogenase activity using 2,3,5-triphenyl tetrazolium chloride (TTC) as a chromogen marker. The red formazan obtained after the TTC reduction in the presence of living cells was quantified and expressed as μg/mL triphenyl formazan (TF). Dehydrogenase activity was determined after 4, 6, and 24h of bacterial cells contact with the test material. To measure the activity, 1 mL of sample was transferred to an Eppendorf tube, over which 100 μL TTC (5 mg / mL) was added. The reaction mixture was incubated at 37°C, for 30 minutes, then centrifuged for 3 minutes at 4000 rpm, and the obtained supernatant was removed. Formazan was extracted with 50% ethanol and spectrophotometrically determined by measuring the absorbance at 484 nm using ethanol as blank. A control sample, represented by the bacterial culture, was also prepared [29]. The experiments were performed in triplicates.

2.5 Scanning electron microscopy of treated bacterial cells

The bacterial suspension was prepared as described in the antibacterial activity experiments. After 4 hours of exposure of *E. coli* bacterial strain to selected materials, the cells were washed twice with distilled water, fixed with 5% (w/v) glutaraldehyde solution and dehydrated in a graded series of ethanol, as described by Stancu [30]. Analytical scanning electron microscope (JEOL JSM-6610) was used to examine the surface morphology of both treated and untreated *E. coli* bacterial strain.

2.6 Repetitive Sequence-Based PCR (rep-PCR)

After 4 hours of contact of the bacterial cells with the synthesized ZnSe materials, DNA extraction was performed using DNeasy Blood&Tissue Kit (Qiagen) according to the manufacturer's instructions. For rep-PCR amplification, 1 µL of extracted DNA was used in a total volume of 25 µL reaction mixture that included dNTP mixture, $MgCl_2$, $(GTG)_5$ primer [31], and Taq DNA polymerase (Promega) dissolved in the corresponding buffer. The PCR amplifications were performed in a Mastercycler pro S (Eppendorf). Thermal cycling parameters were as follows: initial denaturation at 95°C for 6 min, 30 cycles of denaturation at 94°C for 1 min, annealing at 50°C for 1 min, extension at 65°C for 8 min, and a final extension at 65°C for 16 min. The reaction products were electrophoretically separated [32] on a 1.5% agarose gel (w/v) and analyzed after fast blast DNA (Bio-Rad) staining.

2.7 Polymerase chain reaction (PCR) of the 16S rRNA gene

The DNA extraction was performed using the DNeasy Blood&Tissue Kit (Qiagen). For PCR amplification, 1 µL of extracted DNA was used in a total volume of 25 µL reaction mixture containing dNTP mixture, $MgCl_2$, universal bacterial primers 27f and 1492r [33], and Taq DNA polymerase (Promega) dissolved in the corresponding buffer. The PCR amplifications were performed in a Mastercycler pro S (Eppendorf). Thermal cycling parameters were as follows: initial denaturation at 94°C for 10 min, 30 cycles of denaturation at 94°C for 1 min, annealing at 55°C for 30 sec, extension at 72°C for 2 min, and a final extension at 72°C for 10 min. The reaction products were electrophoretically separated [32] on a 1.5% agarose gel (w/v) and analyzed after staining with fast blast DNA (Bio-Rad).

3. Results and discussions

3.1 Characterization of materials

SEM images show the morphologies of zinc selenide based materials obtained by the hydrothermal method at 120°C (Fig. 1). Sample 1 emphasizes a spherical shape with a micrometric diameter (Fig. 1a). In the case of sample 2, SEM micrographs (Fig. 1b) revealed a flower-like structure of ZnSe constituted by well-oriented and smooth, rectangular sheets. These emphasize nanometric thickness (<10 nm) and width (500nm) but lengths in micrometric range (1-2µm).

XRD measurement (Fig.2) identified stilleite as single crystalline phase (2Θ= 29.6, 45.3, 53.7, 66, 73, ICDD 01-071-4771) for powder containing spheres, while a lower crystallinity and very low amounts of secondary phases as $ZnSeO_4.H_2O$, for example [35] were obtained for flower type structures.

According to nitrogen sorption analysis, (Fig.3), the resulted surface area (S_{BET}) values were 15 m²/g for spherical ZnSe samples and 30 m²/g for the flower-like structures.

The adsorption and desorption branches presented in Fig.3 a indicate for the ZnSe spheres a quite irregular porosity which consists in

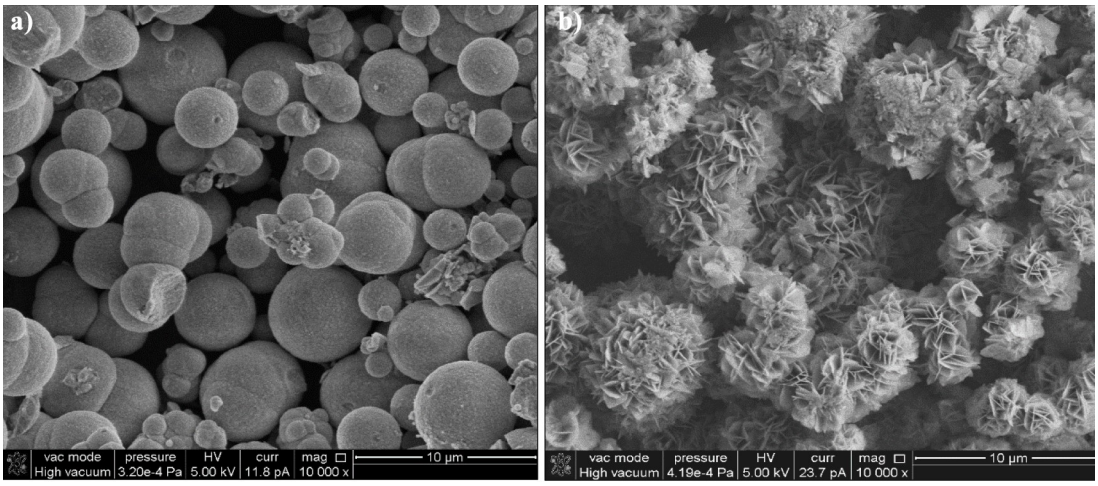


Fig. 1 - SEM micrographs of synthesized ZnSe based materials:
a) ZnSe spherical morphology; b) ZnSe flower type morphology / *Micrografii SEM ale materialelor de ZnSe sintetizate: a) sfere de ZnSe; b) ZnSe cu morfologie tip floare.*

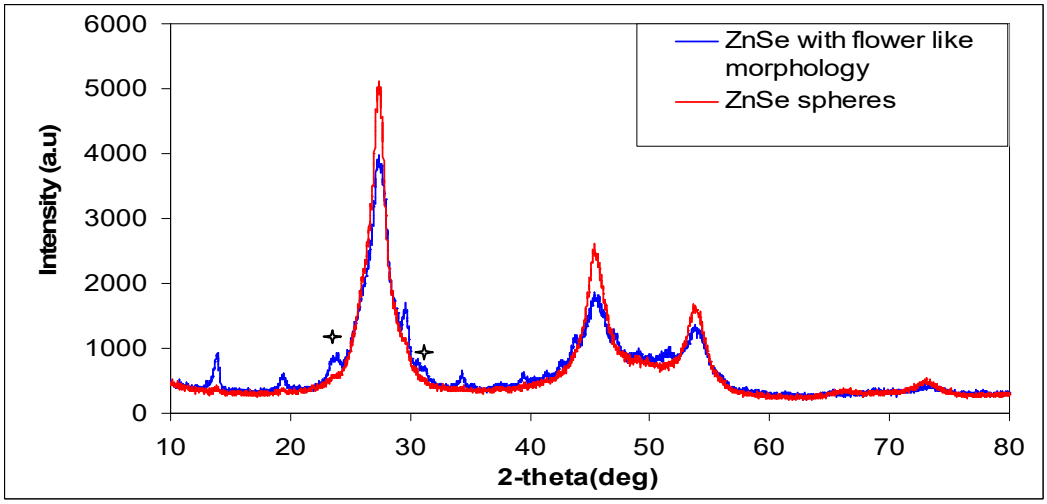


Fig. 2 - XRD pattern of ZnSe materials: (+) Represents $ZnSeO_4.H_2O$ phase
Spectrul difracției de raze X (XRD) pentru materialele de ZnSe: (+) reprezintă faza $ZnSeO_4.H_2O$

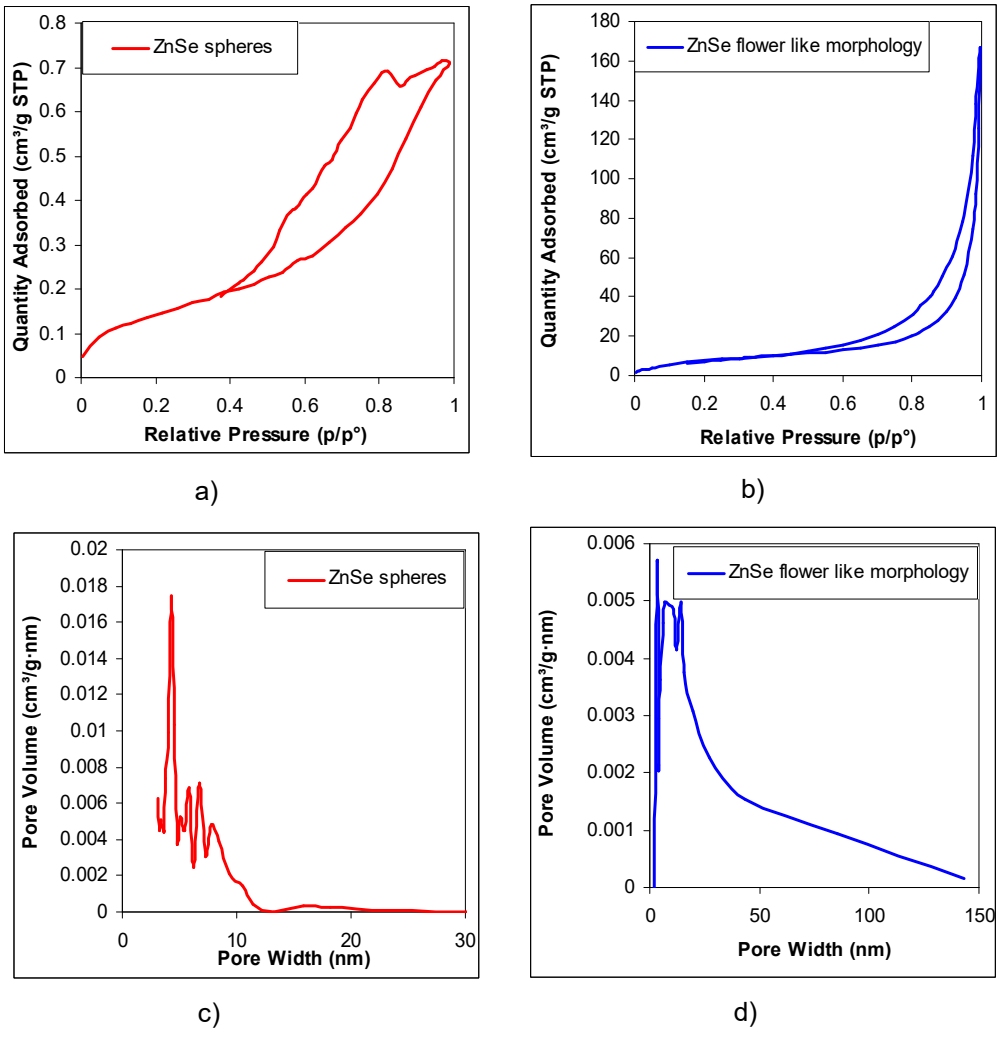


Fig.3 - N_2 adsorption-desorption isotherms (a),(b) and the pore size distribution obtained from the desorption branch (c), (d)/ *Izotermele de adsorbţie-desorbţie a N_2 (a), (b) și distribuția dimensiunii porilor obținută din ramura de desorbție (c), (d).*

intragranular and surface pores and could be assigned also to the intergranular packing. In addition to this, Fig.3c emphasizes the size pore distribution ranging between 3 and 7nm and shows

Table 1

Zeta potential of ZnSe materials measured in aqueous solution
Potențialul zeta al materialelor de ZnSe măsurat în soluție apoasă.

Sample/Proba	Zeta Potential [mV]/ Potențialul zeta [mV]
1. ZnSe (spheres)	-26.3
2. ZnSe (flowers)	-13.3

the main peak being located in between 3-5 nm. The ZnSe sample with flower-like morphology, Fig 3b) shows a well-defined hysteresis loop. The adsorption and desorption branches are almost parallel and suggest an open porous structure generated by the walls of crystalline sheets packed in the flower-like morphology. In this case, the intragranular porosity is significantly lower compared to spherical sample (Figs.3 c and d indicates a pore volume of 0.005 cm^3/g nm compared to 0.018 cm^3/g nm) which is consistent with a pore diameter ranging between 1-15 nm. The porosity resulted by the packing of crystalline sheets extends to macroporosity domain (pore width > 100 nm, Fig 3d).

Further investigations concerning zeta potential measurements have identified negative surface charge in aqueous media for all synthesized samples, the higher negative value being registered for the spherical one (Table 1). As could be seen, zinc selenide nanoflowers display a larger surface available for direct interaction with bacteria compared to micro-sized ZnSe spheres. Thus, taking into account the morphological differences of the prepared materials, a different response of the bacterial cells resulting from the interaction with these inorganic materials was expected.

3.2 Antibacterial activity experiments

Antibacterial activity of synthesized zinc selenide materials after 4, 6, and 24 hours contact time with *E. coli* ATCC 25922 bacterial cells in LB culture medium is illustrated in Figs. 4 and 5. Two different concentrations (0.05 mg/mL and 0.5 mg/mL) of materials were tested to examine possible changes in cellular viability. There were observed significant differences in the antibacterial capacity of the materials, depending on their size and concentration. The results indicated that the antibacterial activity is strongly dependent on the material morphology and its textural properties, a decreased antibacterial activity of ZnSe spheres being registered unlike for the flower type structure. The bacterial reduction percentage obtained for the micro-sized ZnSe spheres with a concentration of 0.05 mg/mL was 20.8% after 4 hours of incubation, but no prolonged inhibitory effect was observed. By increasing the concentration to 0.5 mg/mL, no growth inhibition was observed compared with the control. As shown in Fig. 4, the response of *E. coli* cells to the action of ZnSe with flower-like morphology after 4, 6, and 24 hours of incubation was different. Thus, when a low amount of suspended material (0.05 mg/mL) was used, we found that the bacterial strain exerted a good resistance; the materials did not affect bacterial growth. In contrast, at 0.5 mg/mL, flower type ZnSe inhibited the growth of *E. coli*. Thus, after 4 and 6 hours of the contact between bacterial strain and ZnSe with flower-like morphology, the bacterial reduction was 25% and 27.1%, respectively. When a longer incubation (24h) was applied, the bacterial reduction percentage increased remarkably, resulting in a bacterial reduction of 85.1%, compared with the control sample.

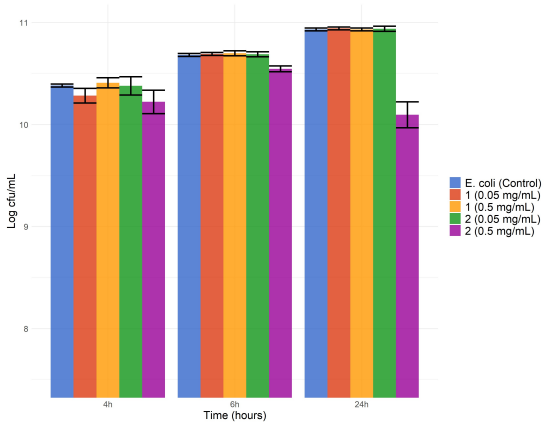


Fig. 4 -Viable cells count (Log cfu/mL) of *E. coli* grown on LB agar plates after 24h of incubation at 37°C. The bacterial strain was grown in the presence of 0.05 and 0.5 mg/mL of ZnSe materials and after 4, 6 and 24h of incubation, cultures were diluted and plated in triplicate on culture medium / *Numărul de celule viabile (Log cfu/mL) de E. coli dezvoltate pe mediul de cultură agarizat, după 24h de incubare la 37°C. Tulpina bacteriană a fost crescută în prezența celor două suspensii conținând materiale pe bază de ZnSe (0, 05 și 0,5 mg/mL), iar după 4, 6 și 24 ore de incubare, au fost efectuate diluții care au fost însămânțate pe mediul de cultură, în triplicat.*

Next, the dehydrogenase activity, an indicator of total biological activity, was assayed to evaluate the response of *E. coli* cells after the treatment with ZnSe materials and to confirm the results obtained by the direct method. The method consists in reducing the TTC compound that is colorless to TF (red triphenyl formazan) by the dehydrogenases of the active metabolic cells. The dehydrogenase activity is colorimetrically determined by measuring the triphenyl formazan

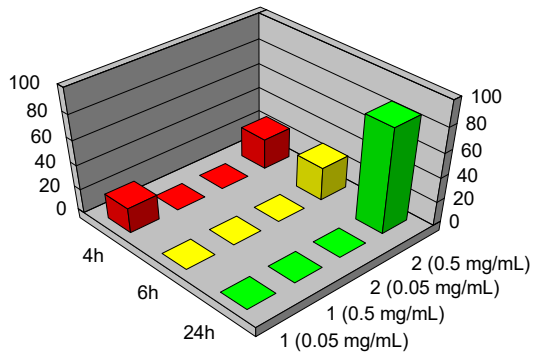


Fig. 5 -The percentage of bacterial reduction after 4, 6, and 24 hours of incubation of the bacterial strain with test materials / *Procentul de reducere bacteriană după 4, 6 și 24 ore de incubare a tulpinii bacteriene cu materialele testate.*

during the reaction, which is directly proportional to the amount of living bacterial cells. In order to determine the dehydrogenase activity, *E. coli* cells were treated for 4, 6 and 24h with two suspensions containing different quantities of zinc selenide based materials, respecting the working protocol for antimicrobial assay by the pour plate method. The results shown in Table 2 were in accordance with those obtained in the previous test, the method proving to be effective in assessing cell viability. This simple and fast experimental procedure allows avoiding the uncertain results obtained by measuring the optical density due to the turbidity of the insoluble synthesized micro- or nanomaterials. Thus, when used suspensions containing 0.05 mg/mL of micro-sized ZnSe spheres, the test indicated a slight decrease in cell viability compared to control only after 4h of incubation. Also, the highest decrease in cell viability occurs 4, 6, and 24 hours after the exposure to suspensions containing 0.5 mg/mL of flower type ZnSe. Considering this finding, in the subsequent experiments, 0.5 mg/mL suspension of flower type ZnSe with 0.5 mg/mL was used for an incubation time of 4h.

3.3 Scanning electron microscopy of treated bacterial cells

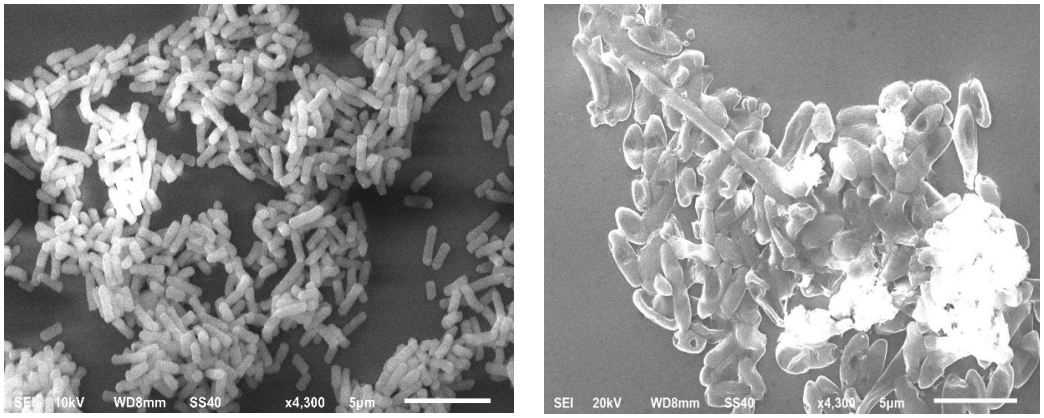
Changes in surface morphology of bacterial surface were observed in the SEM analysis before

Table 2

Dehydrogenase activity of *E. coli* bacterial strain in the presence of synthesized ZnSe materials measured at 4, 6, and 24 hours after bacterial exposure */ Activitatea dehidrogenazică a tulpinii bacteriene E. coli în prezența materialelor sintetizate pe bază de ZnSe, la 4, 6 și 24 ore de la expunere.*

Sample/ Proba	Material suspension (mg/mL)/ Suspensia (mg/mL)	Dehydrogenase activity (triphenyl formazan µg/mL)/ Activitatea dehidrogenazică (trifenil formazan, µg/mL)			
		Initial	T4h	T6h	T24h
1. ZnSe spheres	0.05	0.11	2.08	6.59	13.34
	0.5	0.13	3.67	5.17	12.49
2. ZnSe flower like morphology	0.05	0.13	2.64	7.60	13.14
	0.5	0.11	1.89	2.86	5.82
***E. coli* (Control)**		0.13	3.07	5.65	16.69

Note: The values for dehydrogenase activity are the means of three replicates/
Notă: Valorile pentru activitatea dehidrogenazică reprezintă media a trei replicate.



a) b)

Fig. 6 - SEM micrographs of the control strain and cells treated for 4 hours with ZnSe flower-like morphology using a suspension of 0.5 mg/mL. a) Untreated *E. coli* ATCC 25922; b) *E. coli* treated with flower type ZnSe */ Micrografii SEM ale tulpinii martor și a celulelor tratate timp de 4 ore cu proba de ZnSe cu morfologie tip floare, utilizând o suspensie care conține 0,5 mg/mL material. a) celule netratate de E. coli ATCC 25922; b) celule de E. coli tratate cu ZnSe având morfologie tip floare.*

and after its exposure to the inorganic material, as shown in Fig.6. The untreated *E. coli* cells appeared rod–shaped with a smooth and intact surface. After 4 hours of treatment of the bacterial strain with ZnSe flower type, the SEM micrographs revealed numerous cells with an irregular shape, and cell shrinkage was observed. Most treated cells showed craters on the surface of their membranes, indicating a certain degree of damage to the membrane structure. The values obtained for the zeta potential of the tested materials could explain the way they interact with the bacterial strain. Several studies have reported that electrostatic attraction between negatively charged bacteria and positively charged nanoparticles is the main factor responsible for the antibacterial properties of nanoparticles. As a result of the adsorption of materials onto the cellular membrane, the transport of nutrients and metabolic wastes in and out of the cell may be blocked. Our findings indicate that the attachment of the materials to cell membranes probably occurs through other mechanisms, as previously reported in the literature [23].

3.4 Repetitive Sequence-Based PCR (rep-PCR)

We further investigated if flower type ZnSe with antibacterial capacity could induce modification on a DNA level. DNA extracted from *E. coli* control cells and from the cells exposed 4 hours to synthesized flower type ZnSe was used as templates for rep-PCR using $(GTG)_5$ primer. For the control cells, the amplified banding pattern was between 0.2 and 2.0 kb (Fig. 7a). Similar DNA fingerprints were observed for the cells exposed to flower type ZnSe. The results showed that the exposure of the *E. coli* strain to ZnSe-based materials did not result in changes in repetitive non-coding DNA sequences in the genome of the bacterium.

3.5 PCR of 16S rRNA gene

DNA extracted from *E. coli* control cells and from the cells incubated for 4 hours with synthesized flower type ZnSe sample was also used as templates for PCR of 16S rRNA gene using 27f and 1492r primers (Fig. 7b). In the case of the control cells, two fragments that were approximately 1.5 and 0.8 kb long were obtained; only the 1.5 kb fragment corresponds to the 16S rRNA gene. When the cells were exposed to flower type ZnSe sample, only the 1.5 kb long fragment was detected.

Studies concerning the antibacterial activity of selenium and ZnSe based materials [35] are scarcely found. Moderate antibacterial activity against Gram-positive and Gram-negative bacteria was reported on ZnSe based materials. [28]. Therefore, it is noteworthy that our investigations performed on unmodified ZnSe materials revealed a significant antibacterial activity which is strongly dependent on their morphology, textural properties, and crystallinity. ZnSe sample with flower like morphology, characterized by a higher surface, emphasized a higher ability to reduce the *E. coli* strain than spherical ZnSe in similar conditions. In the case of the flower type ZnSe samples, the different phases present in low amount could contribute also to this effect.

By comparing our results with literature data [36], the antibacterial activity of the synthesized ZnSe materials, especially those with flower like morphology, can be compared with that of ZnO and TiO_2 nanoparticles.

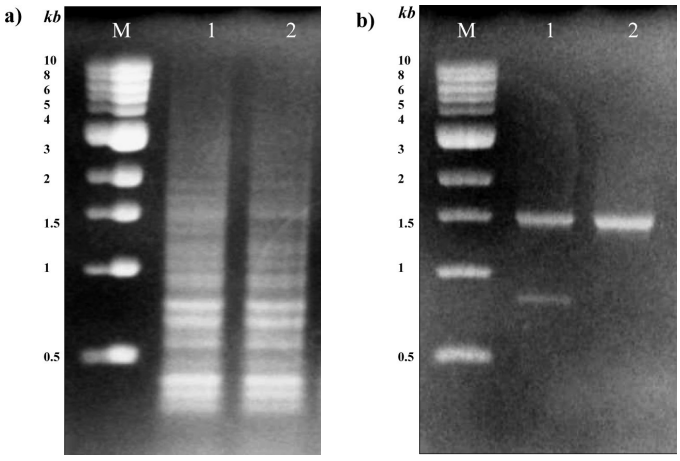


Fig. 7 - a) rep-PCR and b) PCR of 16S rRNA of extracted DNA from untreated and treated *E. coli* bacterial cells after 4 hours of material exposure. **M**:1kb DNA ladder, BioLabs. Lane **1**: untreated *E. coli* cells. Lane **2**: *E. coli* treated with ZnSe flower-like structure */ a) Analiza rep-PCR și b) amplificarea prin PCR a genei pentru ARNr 16S din ADN extras din celule de E. coli martor și tratate timp de 4 ore cu materialul testat. **M**: marker de masă moleculară 1kb (BioLabs). Linia **1**: celule netratate de E. coli. Linia **2**: E. coli tratat cu ZnSe având morfologie tip floare.*

4. Conclusions

The present study investigated the preparation and characterization of the spherical and flower-like ZnSe nanopowders and their antibacterial capacity toward *E. coli* ATCC 25922 bacterial strain related to exposure time and quantity of the inorganic material. The inhibitory effect for micro-sized ZnSe spheres to the *E. coli* cells was low and did not increase with the time of incubation. The antimicrobial activity of zinc selenide based materials obtained by the hydrothermal method is significantly higher for the flower type ZnSe samples than for the spherical one. The suspensions containing 0.5 mg/mL powders of ZnSe with flower-like morphology have shown significant and long-term antibacterial activities toward *E. coli* bacterial strain. SEM images suggest morphological changes of the bacterial cells treated with flower type ZnSe structures - when compared to untreated cells and the PCR of 16S rRNA gene analysis results indicate possible DNA damage. Since different morphologies of zinc selenide materials trigger distinct properties and biological reactivity, more depth studies should be undertaken to understand the mechanism of their antibacterial activity, especially for nanoflowers type zinc selenide materials.

Acknowledgments

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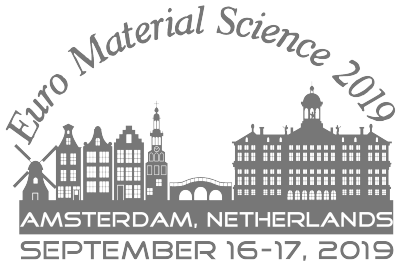
MANIFESTĂRI ȘTIINȚIFICE / SCIENTIFIC EVENTS



September 16-17, 2019 Amsterdam, Netherlands
Theme:
Optimizing the demand of Material Science with the help of recent technologies

The significance of this gathering is to organize researchers, analysts and young researchers to different controls with the aptitudes and capabilities needed to numerous disciplines with the abilities and competencies required to face the challenges of a fast-evolving world. Keeping pace with quickly developing thoughts and advances through quality session has been the fountainhead of the event of our research project. Direct introductions, applicable information, meet with present and potential researchers, create a sprinkle with higher approaches for treatment and mind, and obtain name acknowledgment at this 2-day conference. wide acclaimed speakers, the most recent systems, advancements, and also the most up to this point refreshes in Material Science are signs of this meeting..

Scope and Importance of the Conference

Materials science has incited and added to the rise of different Nano materials, biomaterials, electronic, optical, attractive materials, Surface building, Environmental and Green Materials, Biosensor and Bio-electronic Materials, Carbon Nano Structures and Graphene, Energy Harvesting Materials, Metals and Metallurgy and plan of convoluted structures through the development of innovation by the headways in the investigation of materials science. This gathering is additionally giving a stage to the organizations and additionally foundations to introduce their administrations, items, developments and research comes about.

Target Audience

- Materials Scientists/Research Professors
- Physicists/Chemists
- Junior/Senior research fellows of Materials Science
- Materials Engineers
- Members of different Materials science associations.
- Engineering Professors and Faculty
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