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Synthesis, characterization and cytotoxic effect of ZnO nanoparticles obtained by mechanical alloying

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Abstract

ZnO nanoparticles with different grain sizes have been obtained by mechanical milling, after different treatment times: 3, 6, 12 and 24 hours.
The final products have been characterized by different analytical techniques, such as X Ray Diffraction, Photoluminescence, Fourier transform infrared (FTIR) and UV-Visible spectroscopies.
The cytotoxic effect of one selected concentration ZnO nanoparticles have been evaluated for paramecium growth kinetics and the mortality rate have been recorded as a function of time.
Findings demonstrated that the evolution of the paramecium cell number is clearly affected by ZnO Nps presence.
Keywords: mechanical milling, paramecium, nanoparticles, ZnO, alternative method;

1. Introduction

Nanotechnology is concerned with nanomaterials whose structures exhibit significantly, novel and improved physical, chemical, and biological properties, phenomena and functionality due to their nanoscaled size and to high surface area to volume ratios [1].Oxide Nanoparticles(Nps) (size < 100nm) have also attracted considerable attention because of their potential use in a vast range of applications including nanoparticle-assisted drug delivry, cell imaging and cancer therapy in biomedicine [2] photocatalysis [3] and solar cells [4]. Among them, Zinc oxide (ZnO) has been reported to be effective in inactivating various microorganisms [5] and bacteria [6].

However, the mechanisms involved in these experiences remain the subject of intensive debate because of the complexity of the interaction between the Nps, the cells and the surrounding medium.

The objective of this preliminary work is to contribute to a better understanding, as well as the evaluation, of the ZnO Nps cytotoxic effects on paramecium, by using different parameters that reflects the state of cell metabolism.

2. Experimental

2.1 Preparation of ZnO nanoparticles

Commercial ZnO nanoparticles (99, 99% purity) has been milled during different times (3, 6, 12 and 24 h) in order to obtain ZnO Nps with several grain sizes.

2.2 Characterization of ZnO nanoparticles

The obtained powder has firstly been characterized by X-ray diffraction.

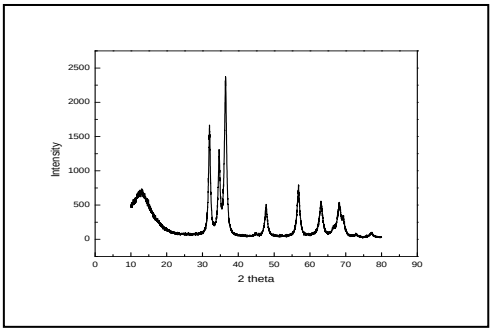

Figure 1 shows an example of X- ray diffraction pattern of ZnO nanoparticles.

2.3. Cytotoxicity effects of ZnO Nps on paramecium

Figure 2 shows the paramecium number variation versus time and that, for 4 different milling time obtained samples.

Moreover, the response percentage of treated paramecium versus time has been illustrated by Figure 3.

3. Results

Fig 1: X ray diffraction of ZnO nanoparticles

It clearly appears that the ZnO is crystalline in nature, and the diffraction peaks matched a hexagonal zincite phase of ZnO, in accordance with the standard ones. No characteristic peaks of any impurities were detected, suggesting that high-quality ZnO was obtained.

In addition, ZnO nanoparticle grain sizes has been deduced from the Debye -Scherrer formula: $D=K\lambda/(\beta\cos\theta)$, where K is the Scherrer constant (0.9 for ZnO), λ the X- ray wavelength (1.54016 Å for Cu $\mathbf{K_\alpha}$ radiation), β the peak width of half maximum and θ the Bragg diffraction angle. The average crystallite size estimated was between 6 and 42 nm.

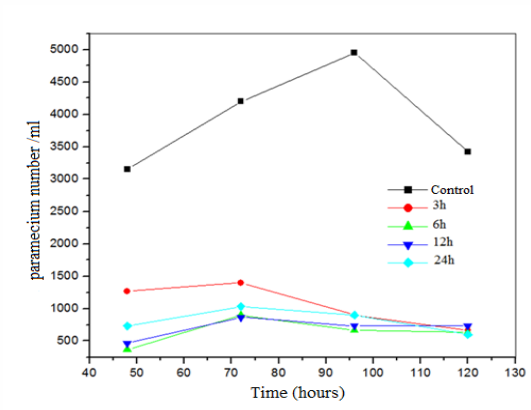

Fig 2 Growth kinetics of the paramecium treated by ZnO nanoparticles as function of time

It appears that the toxicity of Nano ZnO on paramecium cells is quite significant.

Generally, these effects occur primarily by a loss of mobility accompanied disorderly movements of ciliated protists, this brings us to confirm the influence of ZnO Nps within cells, despite the presence of the cell membrane, is a barrier against the massive entrance of xenobiotic but is still permeable.

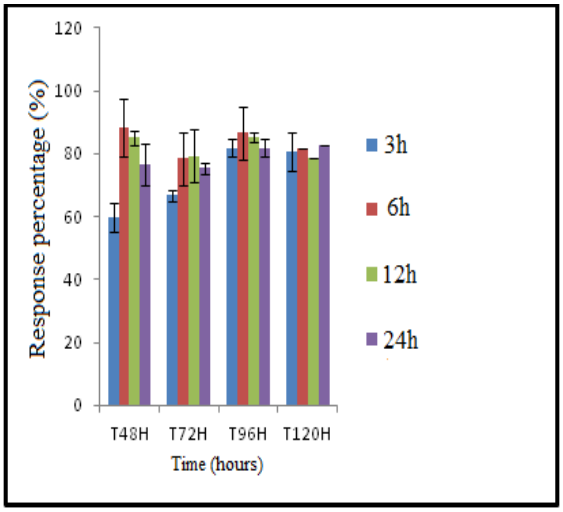

Fig 3 Response percentage of treated paramecium versus time.

The response percentage is a parameter confirms the evolution of growth curves paramecia treated with different grain size of ZnO Nps.

The chemical stress releases free radicals in the cell which leads to an alteration (peroxidation) of cellular components (lipids, proteins) so the membrane.

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