Optimization of a nanoparticle nebulization system to fight insect pests

J. Querol-Donat[a], M.A. Ochoa-Zapater[a], F.M. Romero[b], A. Ribera[b], A. Torreblanca[a], G. Gallello[c], **M.D. Garcerá[a,*]**

[a] Departamento de Biología Funcional y Antropología Física, Universitat de València, Dr. Moliner 50, 46100 Burjassot, Valencia, Spain.
[b] Instituto de Ciencia Molecular, Universitat de València, Catedrático José Beltrán, 2. 46980, Paterna, Valencia, Spain.
[c] Departamento de Química Analítica, Universitat de València, Dr. Moliner 50, 46100 Burjassot, Valencia, Spain.
*garcera@uv.es

Abstract

Introduction

Nanotechnology is a new field of research with great potential that can contribute with great benefits in electronics, optics, medicine, and agriculture. One of the most interesting agricultural uses would be in the fight against pests. Nanoparticles (NPs) can serve as a vehicle for insecticides, reducing both the amount of active compound required and waste generated in the environment. The NPs could facilitate a more direct penetration into the individuals and their target organs, and limit or delay the emergence of resistance to these compounds. One of the main entry routes of the current insecticides is the airway. The aim of this study is to observe if there is penetration of NPs by nebulization, in order to study the possibilities of employing NPs functionalized with insecticides. Our aim is to develop a methodology to nebulize NPs to treat insects.

Methodology

Gold nanoparticles (AuNPs, average size of 21,8 nm) were synthetized as described by Bastús *et al*. [1] and were characterized by UV-Vis and Transmission Electron Microscopy (TEM). The nebulization system used is the "Mass Dosing System" from Buxco® Electronics, Incorporated, Wilmington, NC, USA, a system originally designed for small mammals. Adult *Blattella germanica* individuals (15 males and 15 females, aged 1-6 days) were exposed to nebulized AuNPs and kept inside the nebulization chamber for periods of time ranged between 15 and 90 minutes. *Blattella* can keep closed its spiracles and its tracheal system for 20-30 minutes so a minimum time of exposure is required to secure that cockroaches inhale the nebulized AuNPs [2]. Volumes of 1 and 2 mL of AuNPs in sodium citrate ($2{,}2\cdot10^{-4} \pm 7\cdot10^{-6}$ g Au/L), with variable percentages of duty (percentage of nebulized solution per cycle, one cycle is 6 seconds) between 5% and 100% were studied. Half of individuals were frozen for the measurement of the amount of gold penetration at time 0 while the other half was monitored to control mortality rates for 96 hours and frozen as well at the end of the bioassay. ICP-OES technique (Inductively Coupled Plasma Optical Emission Spectroscopy) was used to measure gold intake in treated cockroaches.

Results

With this nebulization system we could study the differences in nebulization times depending on duty percentages and volumes used. Also, we could observe that AuNPs nebulization times were longer than control nebulization times (figure 1). Although mortality rates were not significant, treated individuals showed hyperactivity and an increase of voracity [4]. The ICP-OEs technique results showed that for any time and percentage of duty tested, gold was detected in all treated insects at time 0, indicating that this system is suitable for the administration of nanoparticles to the insects' tracheal system [3]. However, gold was not detected after 96h after treatment. A higher amount of accumulated gold was observed when the nebulized volume of AuNPs solution was increased (Fig. 2).

Acknowledgements: this work has been supported by grant AGL2010-21555 from the Ministerio de Economía y Competitividad.

References

[1] N.G. Bastús, J. Comenge, V. Puntes, Langmuir, **27** (2001) 11098-11105.
[2] G.K. Snyder, B. Sheafor, D. Scholnick, C Farrelly, J. theor Biol., **172** (1995) 199-207.
[3] R. Posgai, M.G. NielseN, S.M. Hussain, J.J. Rowe, M. Ahamed, Science Toxicology Environmental **408** (2009) 439-443.
[4] Z. Yann, A. Rocha, C.J. Sanchez, H. Liang, Nanoparticles in Biology Medicine **906** (2012) 423-433.

Figures

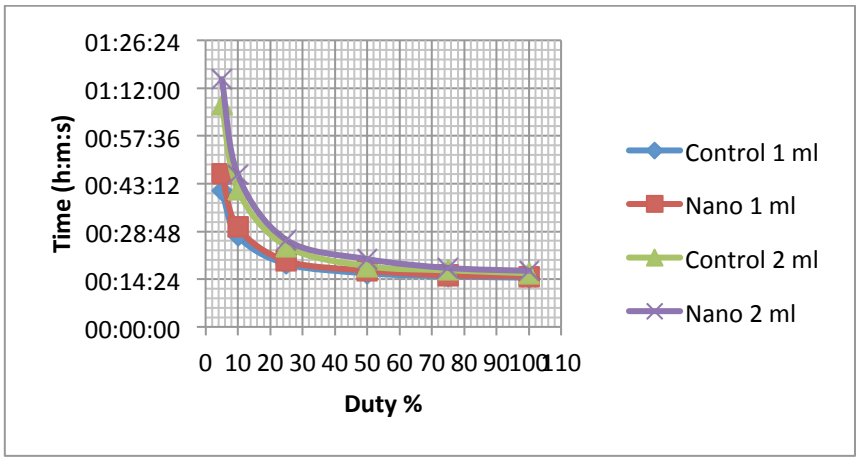

Figure 1: Total nebulization time depending on the treatment (control or nanoparticle) and the percentage of duty.

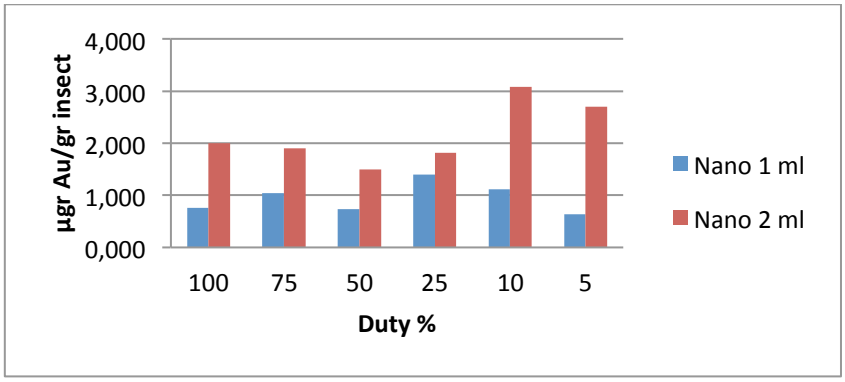

Figure 2: Quantity of gold in µg Au/gr insect compared to nebulized volume (mL) and duty (%).