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RESEARCH ARTICLE

Entomotoxic effect of Aerosil 200 Nano Particles against three main stored grain insects

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Abstract

Laboratory experiment was conducted to evaluate the toxicity of fumed silica, Aerosil 200 nano particles (99.8% Sio_2) against three main stored grain insects which are cosmopolitan and serious pests of cereals and legumes. These insects are, rice weevil, *Sitophilus oryzae,* lesser grain borer, *Rhyzopertha dominica* and cowpea beetle, *Callosobruchus maculatus* at 28±2 ° c and 65±5 % R.H. Results showed that, at the highest conc., 1gm/kg for *C.maculatus, 1.5 gm//kg for R.dominica and 2.5gm/kg for S.oryzae,* complete mortality (100%) was observed on 2[nd], 3[rd] & 6[th] day from treatment with *C. maculatus*, *R. dominica* and *S. oryzae*, respectively. Complete reduction in F_1-progeny was recorded at all concentrations with *C.maculatus* and with *R.dominica* except the lowest conc. while, reduction in F1-progeny with *S. oryzae* ranged from (67-100%). Characterization of nano particles by transmission Electron Microscope (TEM) indicates that the original morphology of particles approximately spherical with the diameter varying between 5 to 20 nm.

INTRODUCTION

Post-harvesting grain crops are exposed to many insect pests causing extensive damage in yield. This loss in weight and quality could be prevented either by use of pesticides or by non-chemical materials such as inert dusts which particularly those based upon activated silicas. Silica is the common name for materials composed of silicon dioxide (SiO2) and occurs in crystalline and amorphous forms. Amorphous silica can be classified into different groups depending on their composition and particle size (e.g. diatomaceous earth, silica aerogels and nano silica) (Dorota et al., 2010) which have been increasingly finding use in commercial storage in the developed world replacing conventional chemicals (Golob,1997). Fumed silica, AEROSIL 200 nano particles (size is 5–50 nm) which is synthetic amorphous silica composed of (99.8% Sio_2) also known as pyrogenic silica is available in hydrophilic and hydrophobic (coated) forms. It is used as a matting agent, thickener, and filler in many adhesives and coatings. Fumed silica has also been used as a desiccating agent to kill insects. Nanotechnology is a promising new field of interdisciplinary research. It opens up a wide array of opportunities in various fields like insecticides, pharmaceuticals, electronics and agriculture. The potential uses and benefits of nanotechnology are enormous. These include management of insect pests through the formulations of nanomaterials-based insecticides.

Nanoparticles (NPs), which have at least one dimension in 1–100 nm range (Ball, 2002 and Roco, 2003) can dramatically, modify the physico-chemical properties when compared to bulk materials (Nel et al, 2006). SiO_2 nanoparticles are one of the most popular Nanomaterials which have been used in various fields. (Nitai et al., 2010) proposed the application of surface functionalized nano-SiO_2 as an insecticide to protect agricultural products by overcoming the resistance to conventional insecticides.

The aim of this study was to investigate the entomotoxicity of fumed silica, AEROSIL 200 nano particles against three main stored grain insects which are cosmopolitan and serious pests of cereals and legumes. These insects are, rice weevil, *Sitophilus oryzae,* lesser grain borer, *Rhyzopertha dominica* and cowpea beetle, *Callosobruchus maculatus* at 28±2 ° c and 65±5 % R.H.

MATERIALS AND METHODS:

1- Insect sources:

For starting a culture of tested insects (F.), adults of *Sitophilus oryzae*& *Rhyzopertha dominica* reared on wheat seeds and *Callosobruchus maculatus* reared on cowpea seeds in a glass jars (each of approximately 500 ml) and each jar was covered with muslin cloths and fixed with rubber bands.

To have an initial population of *insect* adults homogenous in age, about 500 adults were introduced into jars containing seeds for egg laying and then kept in an incubator at 28±2°c and 65±5 % R.H. After three days, all insects were removed from the media and the jars were kept again at controlled conditions.

2- Tested material:

AEROSIL 200 nanoparticles (fumed silica) obtained from Taiba Company for scientific services, Egypt.

3- Bioassay test:

Adults of (1-2 weeks old) *S. oryzae* & *R. dominica* and (0-24 hrs old) *C. maculatus* were used for the experiments. Effects of AEROSIL 200 nano particles were determined by contact toxicity assay at different conc. The experiments were carried out in completely randomized design with 3 replications each consisted of 20 insect adults in small plastic screw capped jars containing 10 g of wheat seeds for *S. oryzae* & *R. dominica* and cowpea seed for *C. maculatus*. Seeds in each jar were treated individually with AEROSIL 200. Then, the jars were shaken manually for approximately 1 min to achieve equal distribution on seed (Subramanyam & Roesli, 2000). In one additional set no Aerosil 200 was mixed with seeds and this set served as control. 20 unmated adults of tested insects were introduced into each jar. All bioassays were performed at 28±2^{o}C and 65±5% RH. Insect mortality was checked after 1, 2, 3, 4, 6 and 8 days for *S. oryzae*, 1,2,3,5 and 7 days for *R. dominica* and 1,2,3,4 and 5 days for C. *maculatus*. Reduction percentage in progeny of offspring was calculated by equation (El-Lakwah et al. 1996) after 60 days for *S. oryzae* & *R. dominica* and 30 days for *C. maculates*. The aqueous suspensions of the studied nano particles have been previously characterized by the Transmission Electron Microscope (TEM) (Frederick, 2010).

4) Data analysis

$Lc_{50\&\ LC90}$ values were determined after 1st day with *C.maculatus* and *R.dominica* and 3rd day with *S.oryzae* according to Finney (1971) for the contact method. Slope values of tested compounds were also estimated and toxicity index. Means were tested for significance by the one way analysis of variance (ANOVA). When the ANOVA statistics were significant ($P<0.05$), means were compared using Duncan's multiple range test (Duncan, 1951). Percent of insect mortality was calculated using the corrected Abbot's formula (Abbot, 1925).

RESULTS:

1-Structural study of Aerosil 200:

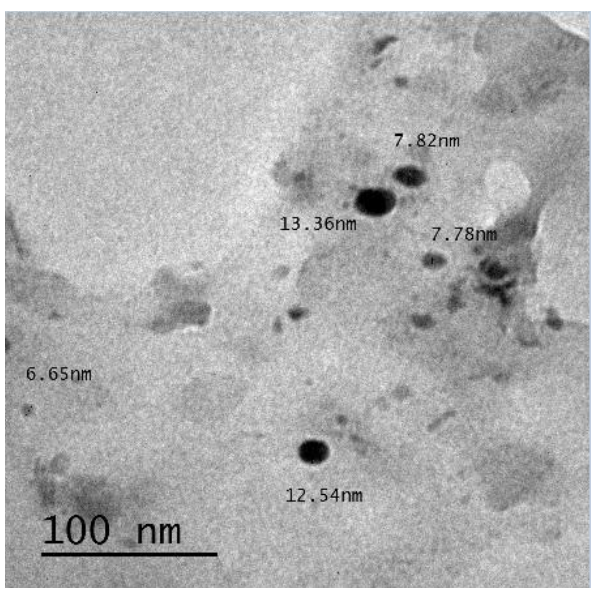

Fig. (1): The TEM images of Aerosil 200 nano particles (x=40)
X: magnification power

The shape and size of Aerosil 200 were checked by transmission Electron Microscope (TEM). Figure (1) indicates that the original morphology of particles approximately spherical with the diameter varying between 5 to 20 nm.

2- Contact toxicity bioassay:

The insecticidal activity of Aerosil 200 with wheat seeds against *S. oryzae* & *R. dominica* and cowpea seeds against *C. maculatus* using contact method is presented in tables (1, 2&3). Analysis of the toxicity data showed that, Aerosil 200 exhibited significant strong toxic effect (P<0.05) against all tested insects with the highest conc. Aerosil 200 significantly increase mortality (%) and reduced the number of progeny when compared to control. Accumulative mortality rate increase with the increasing of concentration and exposure period. Table (3) shows that on the first day, Aerosil 200 was not at all proper effect on *S. oryzae* adults. Since the mortality less than 50% is not efficient.

At the highest conc., 1gm/kg for *C.maculatus, 1.5 gm//kg for R.dominica and 2.5gm/kg for S.oryzae*, complete mortality (100%) was observed on 2nd , 3rd & 6th day from treatment with *C. maculatus, R. dominica* and *S. oryzae*, respectively. Complete reduction in F_1-progeny was recorded at all concentrations with *C.maculatus* and with *R.dominica* except the lowest conc. while, reduction in F1-progeny with *S. oryzae* ranged from (67-100%).

Table (1): Percent mortality (mean ± SE) of *C. maculatus* adults treated with Aerosil 200.

Conc. (gm/kg)	(%)Adult mortality after indicated days					% reduction in F_1 progeny
	1	2	3	4	5	
1	88.3±3.3a	100±0a	100±0a	100±0	100±0	100%
0.5	70±7.6b	98.3±1.7a	100±0a	100±0	100±0	100%
0.25	56.6±4.4b	86.6±2.8a	98.3±1.7a	100±0	100±0	100%
0.1	25±5.7c	61.6±7b	95±5a	100±0	100±0	100%
LSD 0.05	3.6	2.6	1.7	0	0	

Means within a column followed by the same lower case letter are not significantly different (P<0.05).

Table (2): Percent mortality (mean ± SE) of *R.dominica* adults treated with Aerosil 200.

Conc. (gm/kg)	(%)Adult mortality after indicated days					% reduction in F_1 progeny
	1	2	3	5	7	
1.5	80±5.7a	96.6±3.3a	100±0a	100±0a	100±0a	100%
1	63.3±8.7a	76.6±8.7ab	86.6±3.3b	100±0a	100±0a	100%
0.5	43.3±3.3b	66.6±8.7b	83.3±3.3b	100±0a	100±0a	100%
0.25	26.6±3.3b	40±5.7c	60±5.7c	76.6±3.3b	86.6±3.3b	92.5%
LSD 0.05	1.9	2.3	1.2	0.54	0.54	

Means within a column followed by the same lower case letter are not significantly different (P<0.05).

Table (3): Percent mortality (mean ± SE) of *S. oryzae* adults treated with Aerosil 200.

Conc. (gm/kg)	(%) Adult mortality after indicated days						% reduction in F_1 progeny
	1	2	3	4	6	8	
2.5	38.3±4.4a	56.6±4.4a	81.6±6a	91.6±6a	100±0a	100±0a	100%
2	28.3±1.7b	41.6±6b	61.6±4.4b	83.3±7.2ab	95±5ab	100±0a	100%
1.5	20±2.9bc	35±2.9bc	55±2.9b	70±2.9b	83.3±4.4bc	100±0a	89.3%
1	15±2.9cd	26.6±4.4cd	38.3±1.7c	46.6±1.7c	76.6±4.4c	91±3.3a	74.7%
0.5	8.3±3.3d	18.3±4.4d	26.6±6c	36.6±6c	56.6±6d	66±4.4b	67%
LSD 0.05	2	2.3	2.8	3.3	2.8	1.5	

Means within a column followed by the same lower case letter are not significantly different (P<0.05).

3) Data analysis

The probit statistics, estimate of LC_{50}, LC_{90} and the slope of regression lines of AEROSIL 200 nano particles against *C.maculatus* & *R.dominica* after 1st day and *S.oryzae* after 3rd day from exposure was represented in Table (4) and Fig. (2). from probit analysis, it was found that the highest toxicity of Aerosil 200 nano particles was with *C.maculatus* followed by *R.dominica* then *S.oryzae*. When probit regression lines of Aerosil 200 against tested insects were calculated, they showed a linear relationship between mortality percentage and concentration.

Table (4): Relative potency values of AEROSIL 200 nano particles on tested insect adults.

Tested pests	Lc_{50}	Lc_{90}	Slope	Toxicity index (%)
C.maculatus	0.227	1.2	1.79	100
R.dominica	0.586	2.9	1.81	38.7
S.oryzae	1.2	5.6	1.93	18.6

Toxicity index = LC50 of the most effective pesticide/ LC50 of the tested pesticide

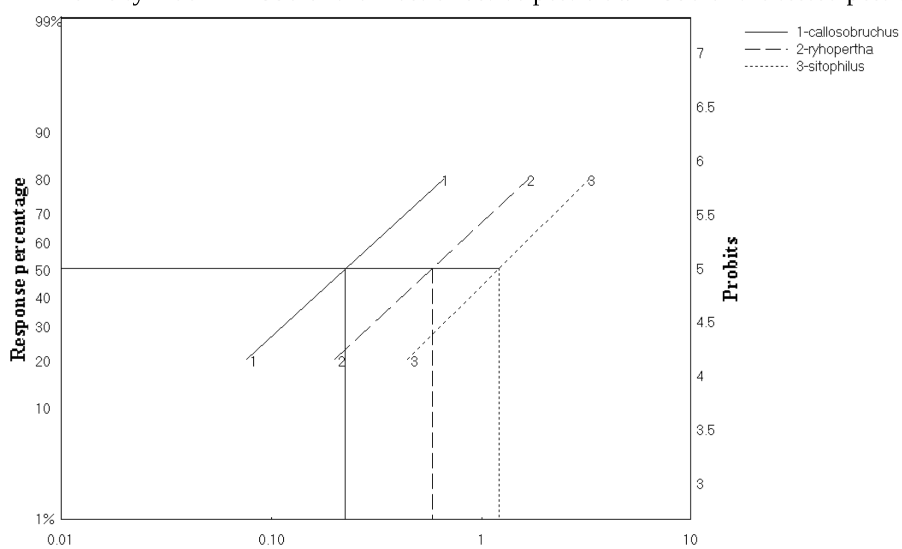

Fig. (2): Toxicity lines of Aerosil 200 nano particles against tested insects

DISCUSSION:

Management of stored-grain pests stands traditionally on use of synthetic insecticides and long term application of these chemicals develops resistance to pesticides. Contact insecticides like some organophosphates and pyrethroides or fumigants unfortunately lead to contamination of food with toxic pesticide residues. Prolonged exposure to these chemicals may lead to neuronal and hormonal disorders (Maryse *et al*. 2010). This lead agro-chemical researchers to reappraise the use of inert dusts as alternative insecticide for crop protection. Inert dusts have been showed to control a variety of common storage insect pests. They are most effective in conditions of low humidity because they induce mortality by causing desiccation; water is lost because the dusts remove the waxy layer of the cuticle of the exoskeleton by adsorption (Maceljski and Korunic, 1972; Le Patourel, Shawir and Moustafa , 1989). However silica aerogels are most effective than diatomaceous earth or other inert dusts, retaining their activity even at elevated levels of relative humidity (Maceljski and Korunic, 1971). Results recorded in this study showed that fumed silica, Aerosil 200 nano particles exhibited significant strong toxic effect ($P<0.05$) against all tested insects and reduce the progeny by 100% at the highest conc. A recent study by (McLaughlin, 1994) compared the efficacy of several diatomaceous earths, silica aerogels and synthetic silica, all of which are commercially available but which varied considerably in particle size against *S. oryzae* and *S. granarius* The fumed synthetic silica, Aerosil was the most toxic when applied as a dust to wheat. Also (Nitai et al., 2010) recorded that Nanoparticles of oxides like SiO_2 produced and characterized in laboratory were tested against insect pests and pathogens. Nanosilica against insect pests shows nearly 100% mortality. Various studies have been taken in use for the detection of the usage of silica nano particles in controlling of stored product pest**.** Insect mortality due to silica nanoparticles treatment was obtained at dose rates almost comparable with those of commercially available DE formulations ranging from 500 to5000 mg kg-1 (Subramanyam and Roesli, 2000; Vardeman *etal.*, 2007). (Barbosa etal. 2000) found that two aerogels, Gasil and Aerosil prevented F1-progeny of *Prostephanus trunctatus* (Horn) more than 6 months after treatment.

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