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List of abbreviations

TX-100	Triton X100
CTAB	cetyltrimethylammonium bromide
PVP	Polyvinyl pyrrolidone
TMOS	Tetramethyl orthosilicate
SiO_2	Commercial silica
NPs	Nanoparticles
SiT	Silica NPs prepared in the presence of T-X100
SiC	Silica NPs prepared in the presence of CTAB
SiP	Silica NPs prepared in the presence of PVP
MS	Mesoporous silica
CK	Commercial kaolin
MK	Meta-kaolin
AMK	Alkaline modified kaolin
PMK	Phosphate modified kaolin
EPPO	European and Mediterranean Plant Protection Organization
EPA	Environmental Protection Agency
AIs	Active ingredients
LC_{50}	The concentration required to achieve 50% of mortality
LD_{50}	The dose required to achieve 50% of mortality
LT_{50}	The time required to achieve 50% of mortality
CI	Confidence intervals
UV	Ultraviolet
Vis	Visible
R.H	Relative humidity
FTIR	Fourier transformation infrared
XRD	X-ray diffraction
BET	Brunauer–Emmett–Teller
BJH	Barrett-Joyner-Halenda
FE-SEM	Field emission scanning electron microscopy
TEM	Transmission electron microscopy
OD	Optical density
NAGA	N-acetylglucosamine
H-E	Hematoxylin-Eosin
PIC	Phase inversion composition
ILs	Ionic liquids

Aim of the work

Pesticides have numerous beneficial effects including crop protection, preservation of food and materials and prevention of vector-borne diseases. Thus, several series of organic pesticides have been developed because of the continuously increasing of the total population over the world. The mode of action of these pesticides is mainly targeting of various systems or enzymes in the pests which might be identical to the systems or enzymes in human beings. Therefore, they caused intensive risks to human health and environment. Considering overall merits of nanomaterials to meet the food security challenges such as targeted delivery of the pesticides, promote the seed germination and plant growth, increase crop yield, improve food quality, control of the pestiferous insects that destroy crops and their products for sustainable agriculture. In the present thesis, we are aiming to develop alternative pesticides based on nanostructured materials. Several nanostructured metal oxides will be synthesized using simple and eco-friendly methods to explore alternative sustainable pesticides for cotton leafworm, *Spodoptera littoralis* (Boisd) control.

Abstract

In modern agriculture, pesticides are playing an important role because they have a powerful biological activity to protect plants from several pests. However, the popular usage of organic pesticides in the entire world causes intensive environmental and health problems. Therefore, many countries are now switching over from chemical-based agriculture to green agriculture, where the utilization of bio-pesticide has a significant role in pest control. In this thesis, we explored alternative inorganic pesticides based on metal oxide nanostructures for *Spodoptera littoralis* (Boisd) control. Several metal oxide nanostructures with controlled particle size and shape have been developed *via* simple wet-chemical methods. The fabricated metal oxides nanostructures were characterized by fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM), transmission electron microscopy (TEM) and N_2 adsorption/desorption isotherms.

Silica nanostructures were synthesised by using soft-template method including different structure-directing agents (i.e. triton X100; TX-100, cetyltrimethylammonium bromide; CTAB, and polyvinylpyrrolidone; PVP). It was found that, the experimental conditions play a significant role not only for controlling the physical properties (size, shape and surface properties) but also reflecting dissimilar entomotoxic effects against *Spodoptera littoralis*. The fabricated silica NPs in presence of PVP (SiP) exhibited the highest entomotoxic effect due to their small particle size. Although the significant pesticidal activity of SiP compared to commercial silica, the

cost of the synthesis methodology is still expensive. Therefore, next attention was turning to simple hydrothermal modification of commercial kaolin using NaOH and Na_2HPO_4 reagents. Such treatment altered not only the physicochemical characteristics of kaolin in terms of shape, crystallinity chemical composition and surface functionality but also their pesticidal activity. It was found that, phosphate modified kaolin (PMK) has a faster entomotoxic effect than NaOH modified kaolin (AMK). The difference in the entomotoxic effect of AMK and PMK might be related to their chemical composition, and surface functionalities. To maximize the usage and applicability of metal oxide nanostructures as a green pesticide, two metal oxides of essential nutrient elements have also applied. Copper and calcium oxides were fabricated *via* template-less method. It was found that, the CuO with flower-like morphology has a faster entomotoxic effect than CaO ceramic sheets. Such bi-functional metal oxides might play a significant role in the development of pesticide formulations.

To explore the mode of action of the metal oxide nanostructures, biochemical analyses and histological changes of treated and untreated/control 6^{th} instar larvae of *Spodoptera littoralis* have been considered. The results showed that, the treated larvae of *Spodoptera littoralis* exhibited intensive damage in mid-gut as well as cuticle abrasion compared to control set (untreated). Hence, the application of metal oxide nanostructures in pest management programs will be helpful for environmental and human health, because they provide an alternative strategy for *Spodoptera littoralis* control with an intelligent mode of action and mitigate the organic contaminations in the environment.