

**DEVELOPMENT OF NANOSTRUCTURED GAS  
SENSING MATERIAL AS AN ETHYLENE GAS  
DETECTOR**

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**DEVELOPMENT OF NANOSTRUCTURED GAS SENSING  
MATERIAL AS AN ETHYLENE GAS DETECTOR**

**by**

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## LIST OF ABBREVIATIONS

Ar	Argon
Sn	Tin or Stannum
SnO <sub>2</sub>	Tin oxide
SnSO <sub>4</sub>	Tin (II) sulfate
Pd	Palladium
Pt	Platinum
PdCl <sub>2</sub>	Palladium (II) chloride
NaOH	Sodium hydroxide
NWs	Nanowires
NSs	Nanostructures
SEM	Scanning electron microscopy
EDS	Energy dispersive spectroscopy
XRD	X-ray diffraction spectroscopy
UV-Vis	Ultra-violet visible spectroscopy
DOE	Design of Experiment
ANOVA	Analysis of variance
CV	Coefficient of variance
ppm	Part per million
ppb	Part per billion
VLS	Vapor-liquid-solid

## LIST OF SYMBOLS

$^{\circ}\text{C}$	Degree Celsius
$\leq$	Less than or equal to
$\Omega$	Ohm
$\Delta G$	Gibbs free energy
%	Percentage
$\text{\AA}$	Angstrom
$\lambda$	Wavelength of Cu-K $\alpha$ line
$\beta$	Full width at half maximum
$\theta$	Bragg angle
K	Shape factor
$\varphi_m$	Schottky barrier
$\mu\text{m}$	Micro-meter
nm	Nano-meter
s	Second

# **PENGHASILAN BAHAN PENGESAN GAS BERSKALA NANO SEBAGAI PENGESAN GAS ETILENA**

## **ABSTRAK**

Gas etilena adalah bahan penting dalam pemasaran produk pertanian segar kerana ia boleh digunakan secara komersial untuk hormon tanaman tiruan, mengawal dan memantau proses pemasakan buah-buahan klimaterik. Menyedari kepentingan alat pengesan gas etilena untuk proses pemasakan buah-buahan, banyak kajian telah dijalankan untuk mengkaji pengaruh gas etilena dalam proses pemasakan tanaman. Nanopartikel tin oxida ( $\text{SnO}_2$ ) adalah bahan yang paling popular untuk mengesan gas etilena kerana ia adalah semikonduktor jenis n yang mempunyai jalur jurang yang luas, justeru itu, menyebabkan rintangan elektrik yang rendah dan pengkonduksian elektrik yang lebih baik untuk alat pengesan gas. Tambahan pula, suhu operasi yang rendah, kepekaan yang tinggi, reka bentuk sensor yang ringkas serta kos pembuatan yang rendah membuat  $\text{SnO}_2$  pilihan terbaik untuk aplikasi pengesan gas. Dalam penyelidikan ini, pemendapan wap kimia (CVD) dan kaedah hidroterma telah digunakan untuk mensintesis nano-struktur  $\text{SnO}_2$  ( $\text{SnO}_2$  NSs). Sintesis, pencirian bahan dan sifat-sifat pengesan gas etilena telah dikaji dengan menggunakan nano  $\text{SnO}_2$ . Pertama sekali, nano-wayar (NWs)  $\text{SnO}_2$  telah disintesis di atas substrat silikon dengan menggunakan kaedah CVD. Kesan daripada pemanipulasian pembolehubah CVD (seperti suhu sintesis, tempoh sintesis, kadar aliran gas argon dan gas oksigen) terhadap dimensi  $\text{SnO}_2$  NWs telah disiasat dengan menggunakan analisa statistik iaitu Reka Bentuk Eksperimen (RBE) oleh perisian Design Expert 6.0.8. Mikroskop imbasan elektron (SEM), spektroskop serakan tenaga (EDS) dan spektroskop pembelauan sinar-X (XRD) telah mengesahkan fabrikasi  $\text{SnO}_2$  NWs.