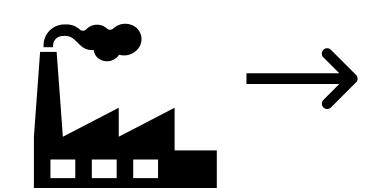


# **Surface Modified Silica Nanoparticles for Nickel Adsorption and Phytoremediation**

Presented by Bethany Chong Yu Lin Supervised by Prof Lam Yeng Ming

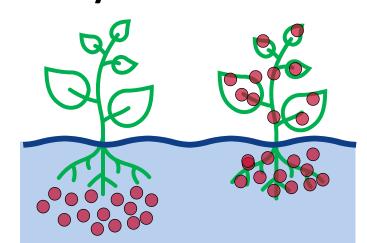
### Introduction

## Heavy metal pollution



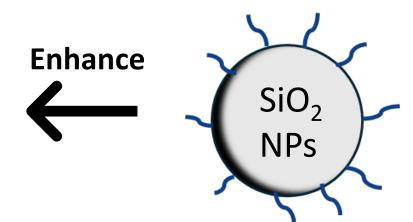
Nickel (Ni) contamination in water especially prevalent [1]

### **Phytoremediation**



Cost effective and environmentally friendly remediation method [2]

#### **Nanomaterials**



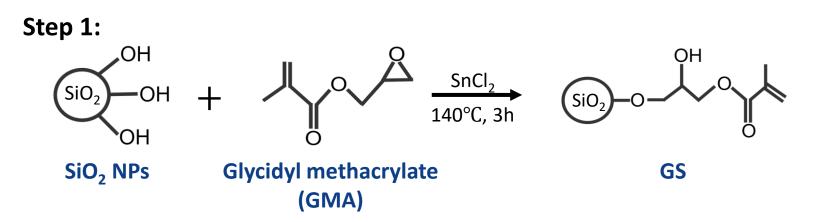
Surface modified silica nanoparticles (SiO<sub>2</sub> NPs)

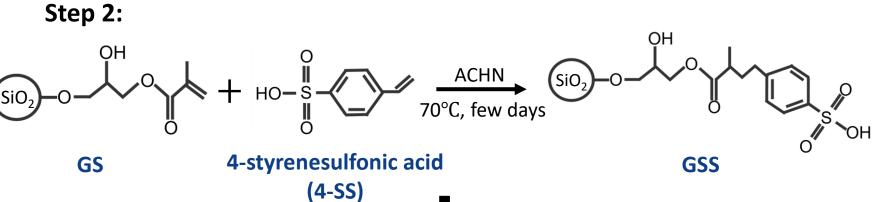
### **Objectives**

- Surface modify SiO<sub>2</sub> NPs with 4styrenesulfonic acid (4-SS) (forming product known as GSS)
- Characterise the modified product
- Analyse the adsorption behaviour of GSS towards Ni(II) ions including the effects of pH, adsorption isotherm, and adsorption kinetics
- Evaluate the potential of GSS in enhancing phytoremediation by assessing its impact on plant growth and Ni uptake

## Methodology

#### **Surface modification**





## Characterisation

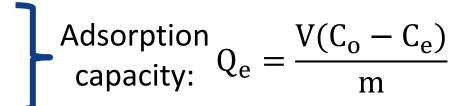
- Scanning/Transmission Electron Microscopy (SEM/TEM)
- Fourier transform infrared spectroscopy (FTIR)
- X-ray photoelectron spectroscopy (XPS)
- Zeta potential analysis

## **4**

### **Adsorption behaviour**

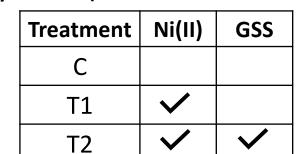
- Batch adsorption experiments
- Effect of pH
- Adsorption isotherm

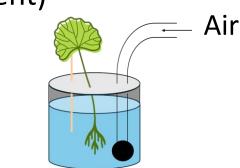
Adsorption kinetics



## Impact on plant growth and Ni phytoremediation

• Centella asiatica (L.) Urban in deep water hydroponic system (1 week treatment)





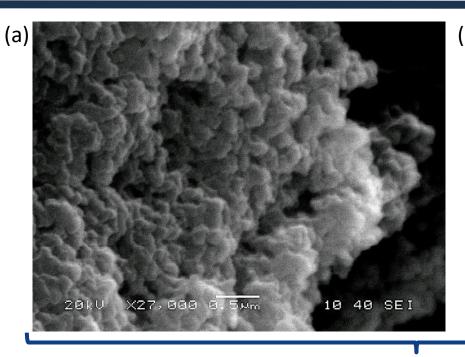
- % change in root and shoot lengths
- Ni(II) concentration in plants
- Bioconcentration Factor (BCF)/Translocation factor (TF)

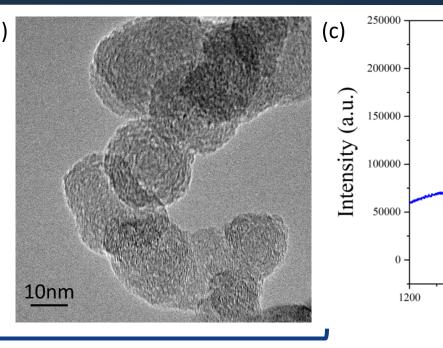
### Conclusion

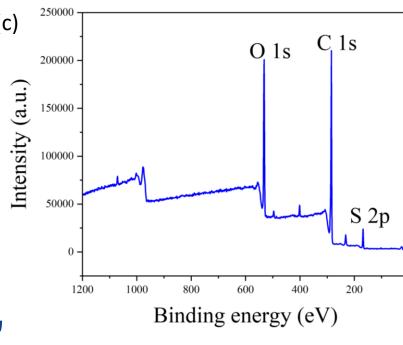
- Adsorption of Ni(II) on GSS is independent of pH, well fitted to Langmuir adsorption model & pseudosecond-order kinetic model
- GSS reduced BCF, TF and Ni(II) concentration in plants. GSS mitigated Ni stress and promoted plant growth. GSS can also act as a carrier for Ni, providing alternate an pathway for uptake
- GSS remains a potential material in enhancing phytoremediation by promoting plant growth

## **Results & Discussions**

### **Characterisation of GSS**

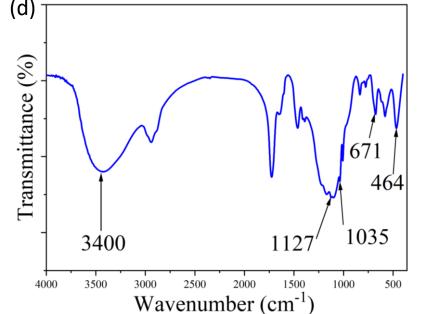


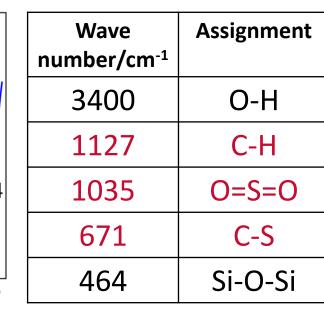


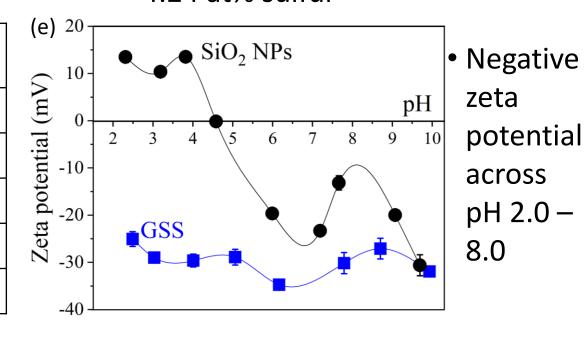


- Layered structure on surface of SiO<sub>2</sub> NPs
- → Successful modification

- Carbon and sulfur emissions
- 4.24 at% sulfur

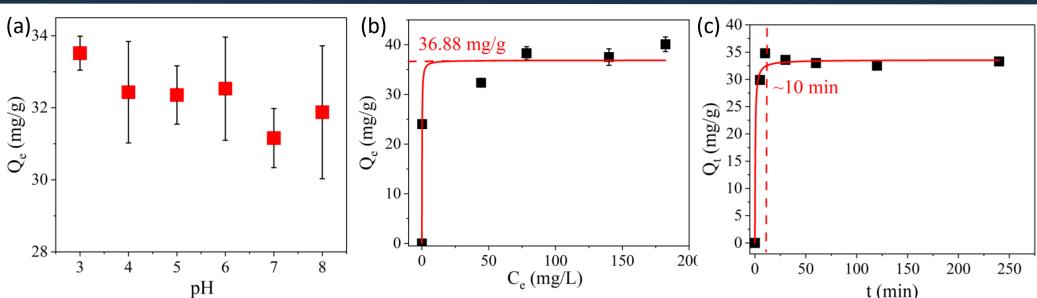






(a) GSS under SEM. (b) GSS under TEM. (c) Wide scan XPS Spectrum of GSS. (d) FTIR spectra of GSS and peak assignment. (e) Zeta potential of unmodified SiO<sub>2</sub> NPs and GSS.

## Adsorption behaviour



- Adsorption relatively independent of pH
- independent of pH

  (a) Effect of pH on adsorption of Ni(II) onto GSS. (b)

Non-linear Langmuir isotherm plot for Ni(II)

adsorption onto GSS. (c) Adsorption kinetics of GSS

for Ni(II). (d) pH of Ni(II) solution before and after

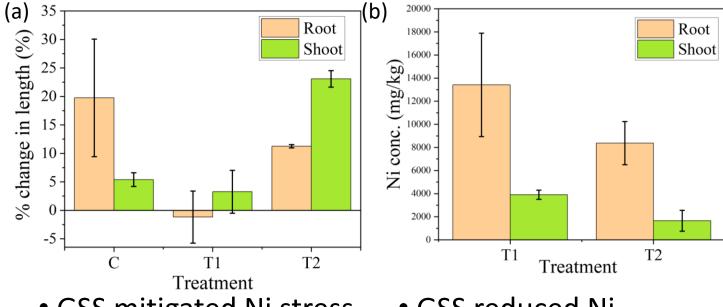
- Langmuir adsorption model (R<sup>2</sup> > 0.99)
- Max  $Q_e$ : 36.88 mg/g (literature:  $\approx$  30 mg/g)
- Pseudo-second-order kinetic model (R<sup>2</sup> > 0.99)
- Time to equilibrium: ≈10min (literature: ≈ 30-60min)
- pH of Ni(II) solution Before After 2.94 2.48 2.63 3.97 5.96 2.63 6.04 2.63 6.96 2.63 7.96 2.68 • pH decreased
- after adsorption

  → Ion exchange

  mechanism at

  sulfonate group

### Impact on plant growth and Ni phytoremediation



 GSS mitigated Ni stress and promoted plant growth GSS reduced Ni concentration in shoots and roots of plants

(a) Percentage change in shoot/root length of plantlets from different treatment conditions. (b) Ni(II) concentration in roots/shoots of plantlets from different treatment conditions. (c) BCF and TF of plantlets in T1 and T2 treatment conditions. (d) SEM-EDS of undigested material from shoots of plantlets in T2

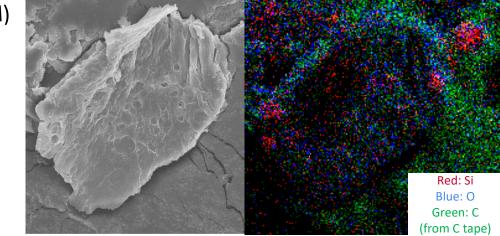
ot	(C)	Treatment	BCF	TF	•
oot		T1	866	0.3	
		T2	501	0.2	
	(4)				

• GSS

• GSS

reduced

BCF and TF



- Si detected in shoots of T2 plantlets (likely from GSS)
- → GSS can act as a carrier for Ni

References

[1] J. M. Costa, J. G. dos R. da Costa, and A. F. de Almeida Neto, 'Techniques of nickel(II) removal from electroplating industry wastewater: Overview and trends', J. Water Process Eng., vol. 46, p. 102593, Apr. 2022, doi: 10.1016/j.jwpe.2022.102593.

[2] R. Dixit et al., 'Bioremediation of Heavy Metals from Soil and Aquatic Environment: An Overview of Principles and Criteria of Fundamental Processes', Sustainability, vol. 7, no. 2, Art. no. 2, Feb. 2015, doi: 10.3390/su7022189.