

## Supporting information

### Effect of ZnMgO<sub>2</sub> nanoparticles used as a nano fertilizer: Promote the growth activities of rice seedling

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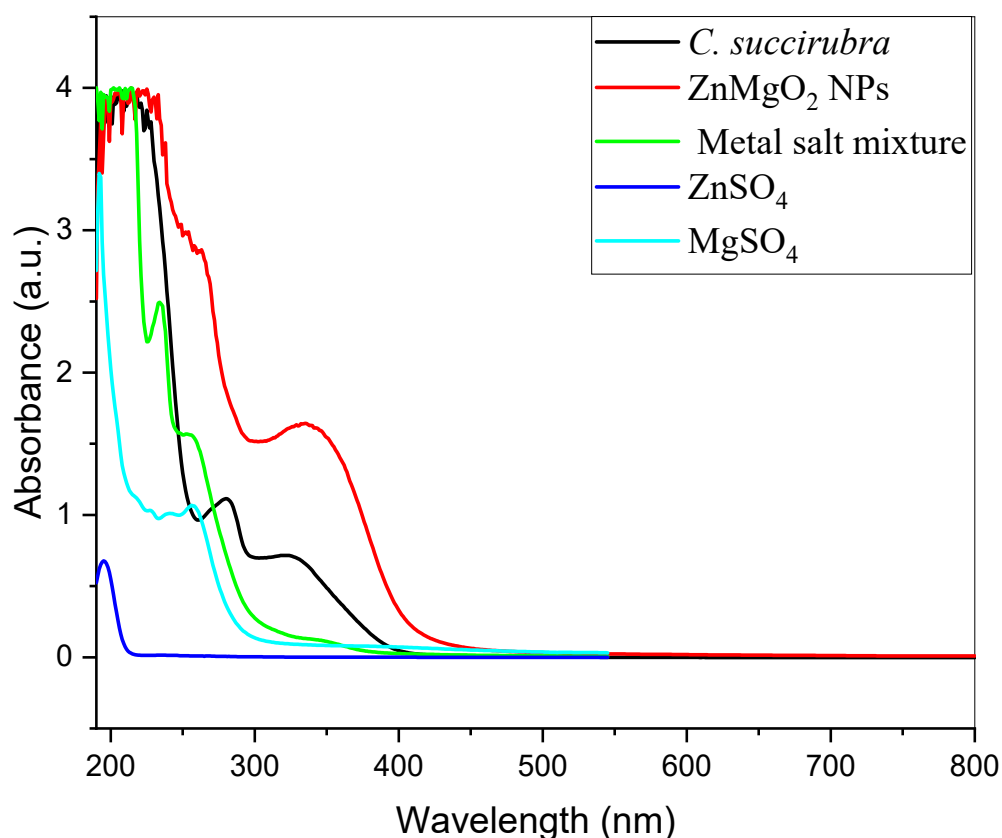
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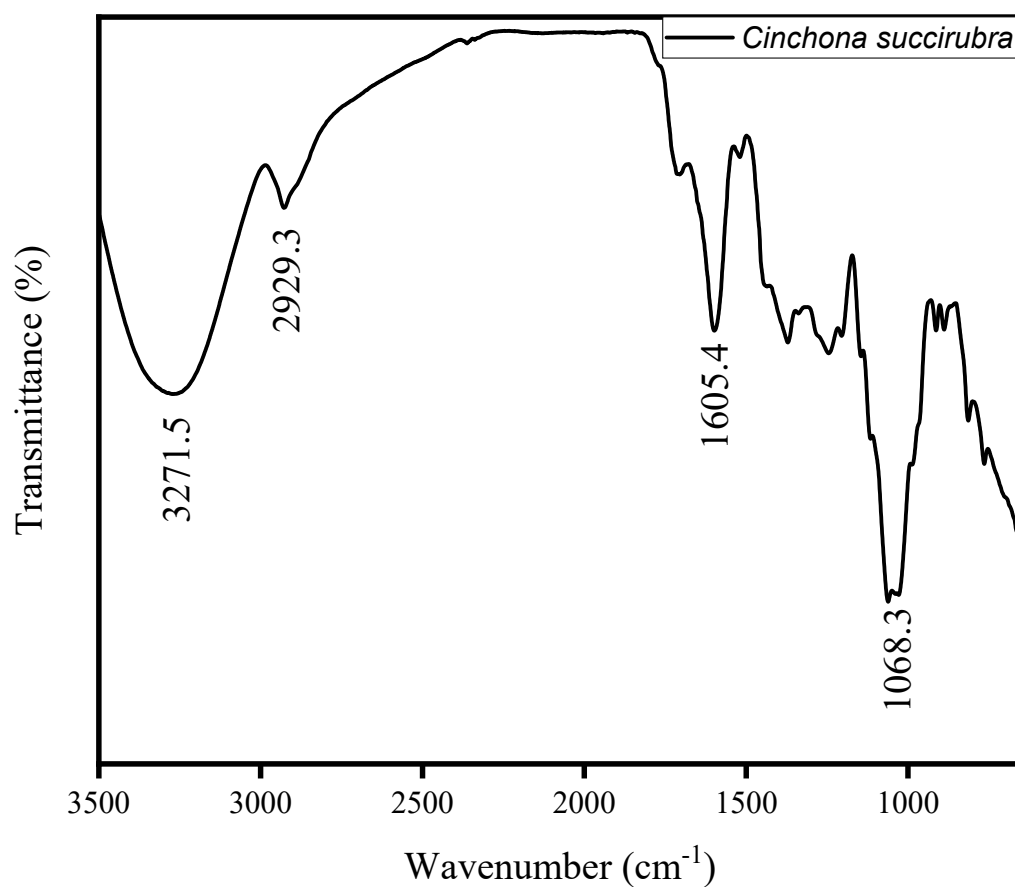


SI Figure 1. UV-visible spectrum of ZnMgO<sub>2</sub> nanoparticles, their salts and *C. succirubra* leaf extract

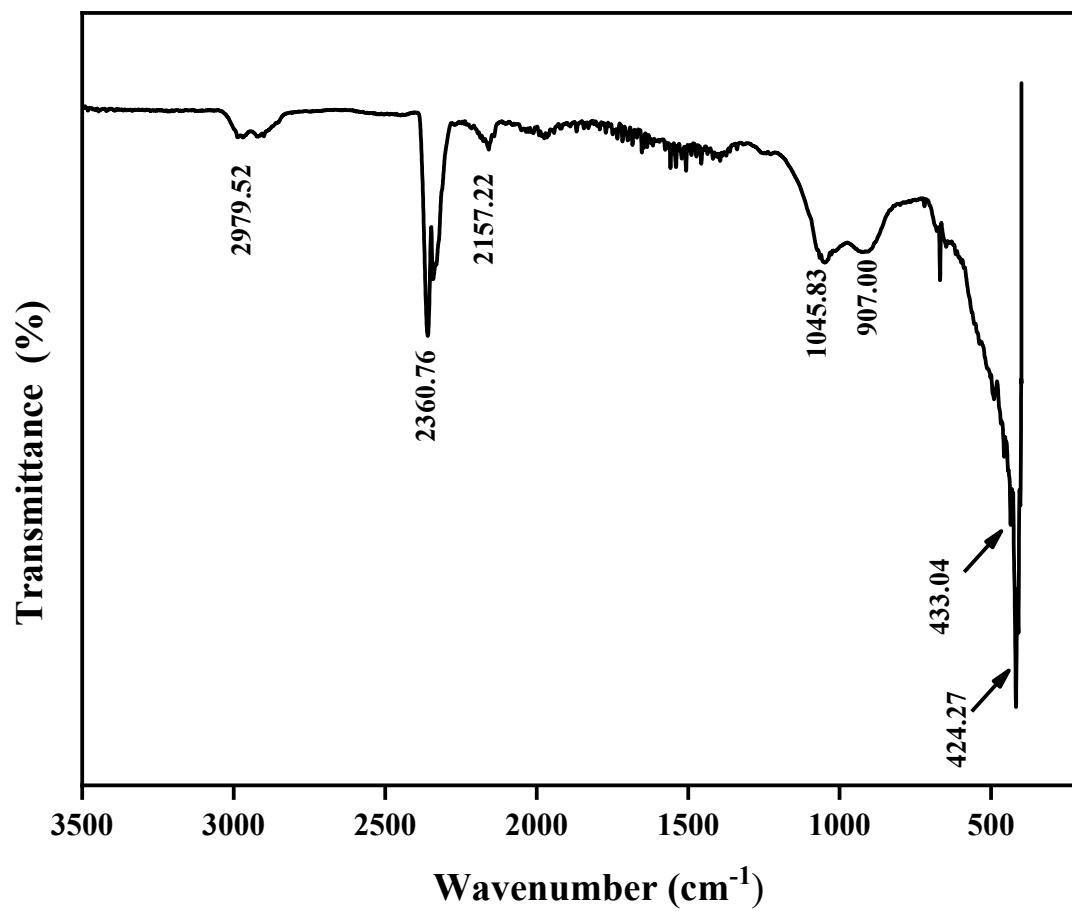
## Synthesis of ZnMgO<sub>2</sub> NPs

*Cinchona succirubra* leaf extract was employed as a capping and stabilizing ingredient by employing the green syntheses approach. Additionally, the phytochemicals included in leaf extract, such as polyphenols, flavonoids, glycosides, and tannins, function as a reducing agent.<sup>1</sup>

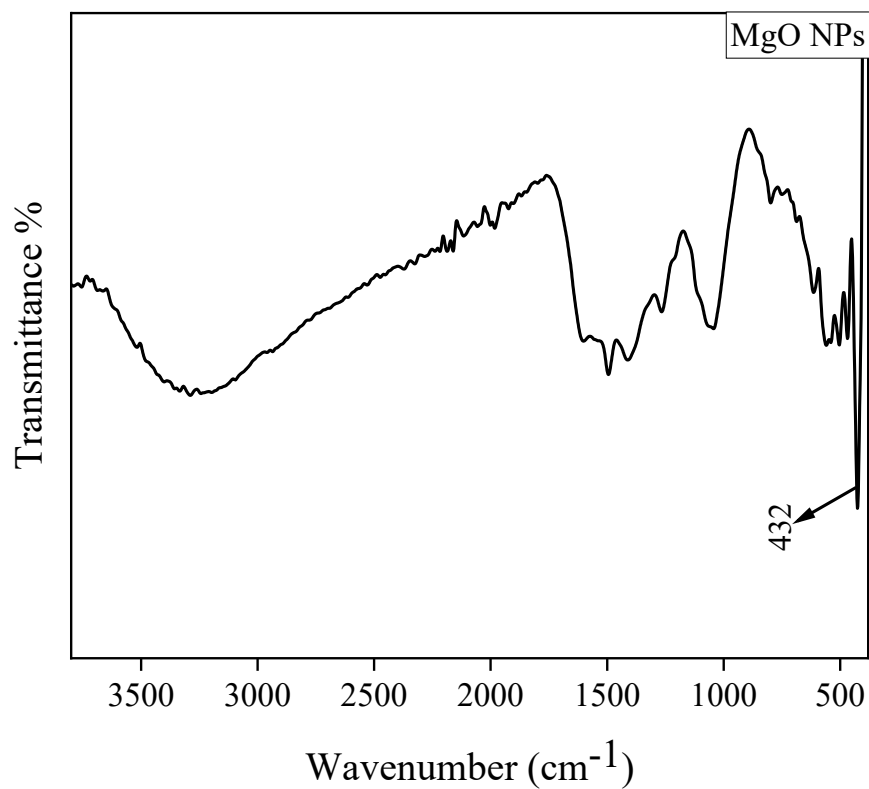
### Fourier Transforms Infrared (FTIR) Spectroscopy



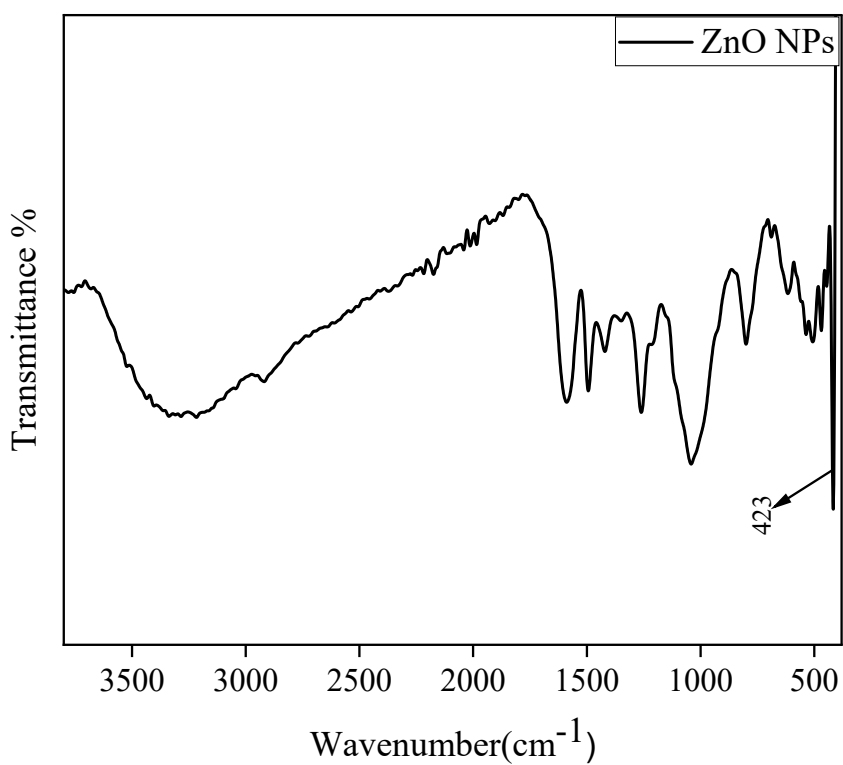
**SI Figure 2.** Fourier-transform infrared spectroscopy (FTIR) spectrum of *Cinchona succirubra* leaf extract



SI Figure 3. Fourier-transform infrared spectroscopy (FTIR) spectrum of ZnMgO<sub>2</sub>.



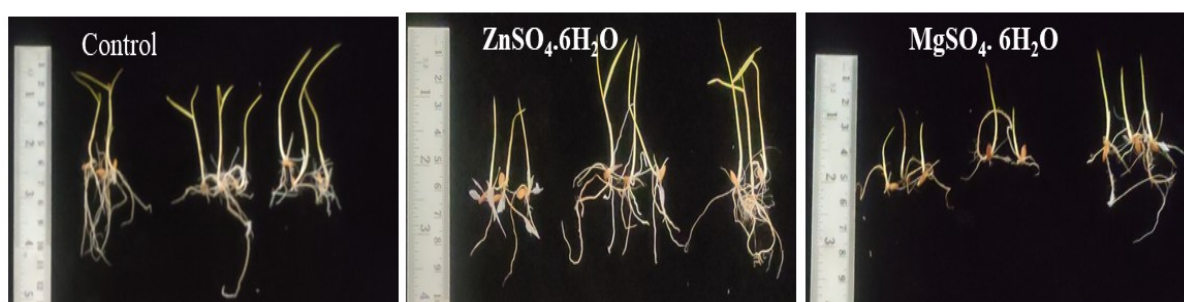
**SI Figure 4.** Fourier-transform infrared spectroscopy (FTIR) spectrum of MgO.



**SI Figure 5.** Fourier-transform infrared spectroscopy (FTIR) spectrum of ZnO.

### Compared chart for M-O stretching frequency in different composites

Composites	Stretching Frequency (cm <sup>-1</sup> )	
	Mg-O	Zn-O
ZnMgO <sub>2</sub> NPs	433.0	424.27
MgO NPs	432	-
ZnO NPs	-	423



SI Figure 6. Images of rice seedlings treated with metal salts (ZnSO<sub>4</sub>&MgSO<sub>4</sub>)

**SI Table 1.** Metal salts treated (ZnSO<sub>4</sub>&MgSO<sub>4</sub>) rice root length.

Samples	Root length (on 7 <sup>th</sup> day)
Control	5.92±0.75 cm
ZnSO <sub>4</sub> 25 mg/L	4.67±1.35 cm
ZnSO <sub>4</sub> 75 mg/L	5.51±0.36 cm
MgSO <sub>4</sub> 25 mg/L	4.36±0.58 cm
MgSO <sub>4</sub> 75 mg/L	4.40±0.68 cm

**SI Table 2.** Metal salts treated (ZnSO<sub>4</sub>&MgSO<sub>4</sub>) rice shoot length.

Samples	Shoot length (on 7 <sup>th</sup> day)
Control	3.75±0.54 cm
ZnSO <sub>4</sub> 25 mg/L	4.76±1.35 cm
ZnSO <sub>4</sub> 75 mg/L	5.54±0.69 cm
MgSO <sub>4</sub> 25 mg/L	4.66±0.68 cm
MgSO <sub>4</sub> 75 mg/L	2.95±0.36 cm

**SITable 3.** Root length of rice seedlings treated with ZnMgO<sub>2</sub> NPs.

Samples	Day 20	Day 40	Day 60
Control	4.25±1.07 cm	4.74±0.83 cm	5.11±1.11 cm
ZnMgO <sub>2</sub> 25mg/L	6.25±0.58 cm	7.35±1.28 cm	7.88±1.28 cm
ZnMgO <sub>2</sub> 75mg/L	7.18±1.29 cm	7.26±0.68 cm	7.35±0.80 cm
Urea (U) 25 mg/L	4.93±0.51 cm	4.87±1.24 cm	5.47±0.88 cm
Urea (U) 75 mg/L	4.46±0.59 cm	4.47±1.06 cm	4.84±0.62 cm

**SI Table 4.** Shoot length of rice seedlings treated with ZnMgO<sub>2</sub> NPs.

Samples	Day 20	Day 40	Day 60
Control	11.88±1.11 cm	14.73±2.95 cm	20.97±3.29 cm
ZnMgO <sub>2</sub> 25 mg/L	16.03±0.71 cm	17.27±1.66 cm	23.90±1.49 cm
ZnMgO <sub>2</sub> 75 mg/L	16.65±2.02 cm	18.36±1.43 cm	22.11±1.90 cm
Urea (U) 25 mg/L	13.75±1.05 cm	14.32±2.21 cm	23.11±2.93 cm
Urea (U) 75 mg/L	15.05±1.44 cm	14.54±1.62 cm	21.31±2.84 cm

**SI Table 5.** Antioxidant content in rice seedlings treated with ZnMgO<sub>2</sub> NPs.

Samples	Days 40	Days 60
Control	0.10±0.004	0.14±0.03
ZnMgO <sub>2</sub> 25mg/L	0.18±0.02	0.39±0.007
ZnMgO <sub>2</sub> 75mg/L	0.14±0.02	0.29±0.07
Urea (U) 25 mg/L	0.10±0.008	0.20±0.39
Urea (U) 75 mg/L	0.25±0.06	0.18±0.009

Note: Antioxidant content was expressed in terms of mg AAE g<sup>-1</sup> FW

**SI Table 6.**  $\alpha$ -amylase activity in rice seedlings treated with ZnMgO<sub>2</sub> NPs.

Samples	$\alpha$ -amylase activity (on 7 <sup>th</sup> day)
Control	22.73±7.05
ZnMgO <sub>2</sub> 25mg/L	29.16±1.12
ZnMgO <sub>2</sub> 75 mg/L	33.15±7.70
Urea (U) 25mg/L	28.51±7.70
Urea (U) 75 mg/L	27.40±3.78

Note:  $\alpha$ -amylase activity was expressed in terms of  $\mu\text{mol}/\text{min}$ .

**SI Table 7.** Phenol content in rice seedlings treated with ZnMgO<sub>2</sub> NPs.

Samples	Day 20	Day 40
Control	0.07±0.02	0.004±0.001
ZnMgO <sub>2</sub> 25 mg/L	0.08±0.01	0.03±0.04
ZnMgO <sub>2</sub> 75 mg/L	0.10±0.01	0.002±0.03
Urea 25 mg/L	0.06±0.01	0.005±0.006
Urea 75 mg/L	0.09±0.03	0.001±0.0001

Note: Phenol content was expressed in terms of mg GAE g<sup>-1</sup> FW



**SI Table 8.** Flavonoid content in rice seedlings treated with ZnMgO<sub>2</sub> NPs.

Samples	Day 20	Day 40
Control	0.03±0.01	0.07±0.03
ZnMgO <sub>2</sub> 25 mg/L	0.05±0.01	0.13±0.02
ZnMgO <sub>2</sub> 75 mg/L	0.04±0.006	0.09±0.02
Urea (U) 25 mg/L	0.02±0.002	0.09±0.01
Urea (U) 75mg/L	0.03±0.01	0.07±0.006

Note: Flavonoid content was expressed in terms of mg QE g<sup>-1</sup> FW

**SI Table 9.** Dose determination of ZnMgO<sub>2</sub>

(a) Root length

Concentration	Root length (Day 10)
25mg/L ZnMgO <sub>2</sub>	6.35±0.79 cm
100mg/L ZnMgO <sub>2</sub>	5.39±0.72 cm

(b) Shoot length

Concentration	Shoot length (Day 10)
25mg/L ZnMgO <sub>2</sub>	5.32±0.79 cm
100mg/L ZnMgO <sub>2</sub>	4.61±0.68 cm

## Reference

- 1 L. N. Al-Harbi, G. M. Al-Shammari, P. Subash-Babu, M. A. Mohammed, R. A. Alkredees and A. E. G. A. Yagoub, *Nanomaterials*, DOI:10.3390/nano12193393.