Uniform volumetric encapsulation of antimicrobial agents into mesoporous silica for their slow release: the case of copper oxide

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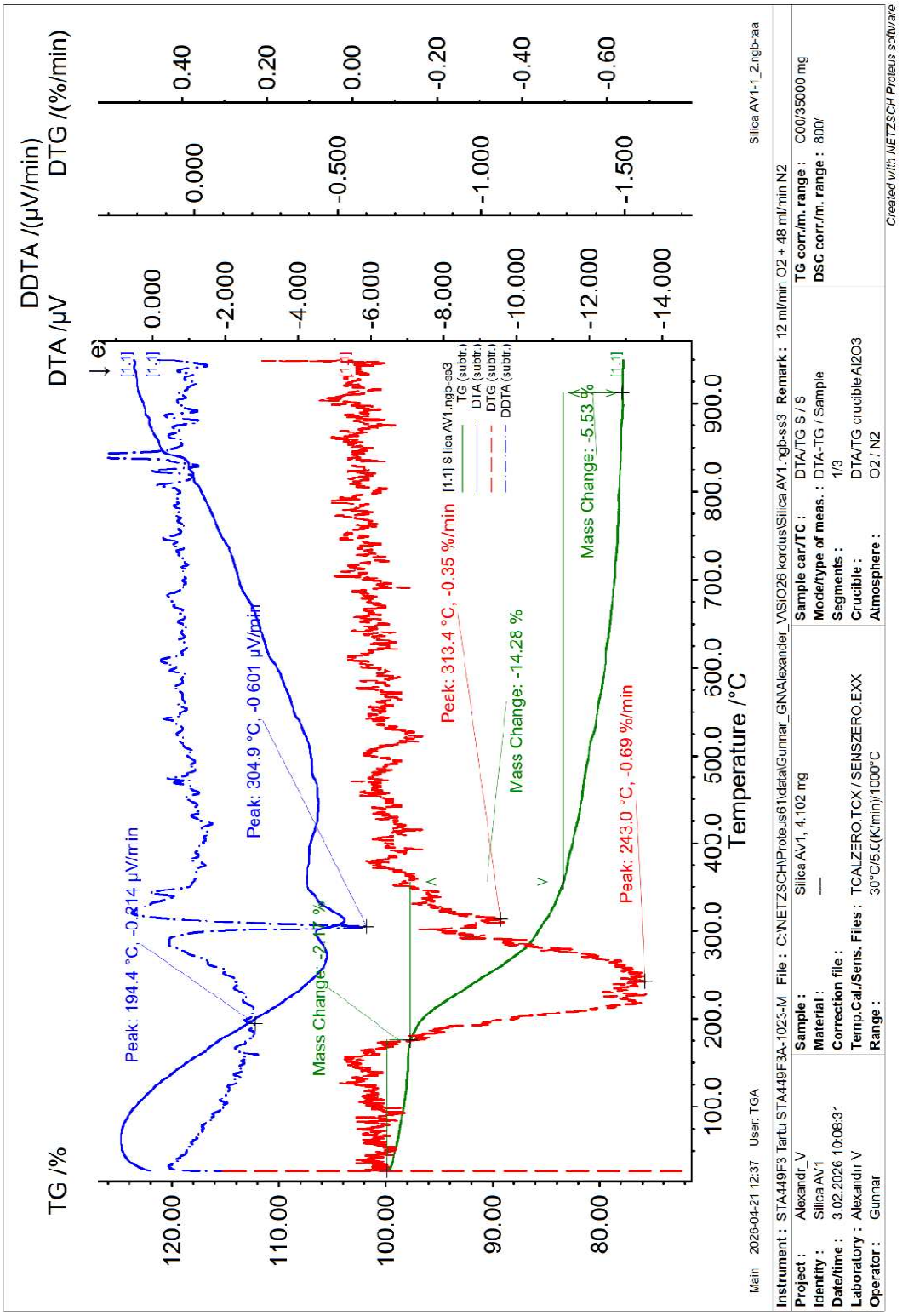


Figure S1. DT/TGA of as prepared SiO_2 sample.

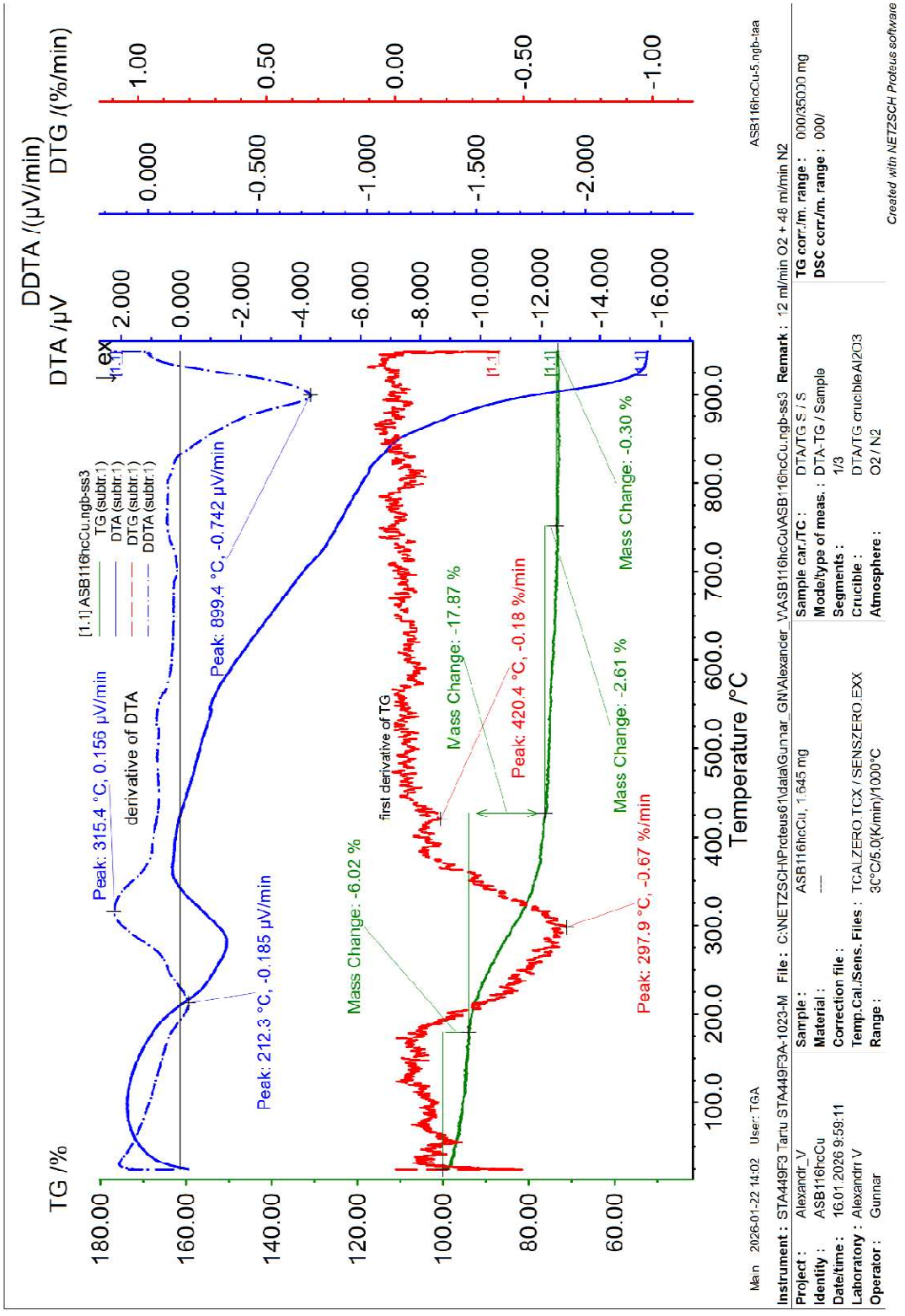


Figure S2. DT/TGA of $[Cu(NH_3)_4]^{2+}$@SiO_2 (5.5%) sample.

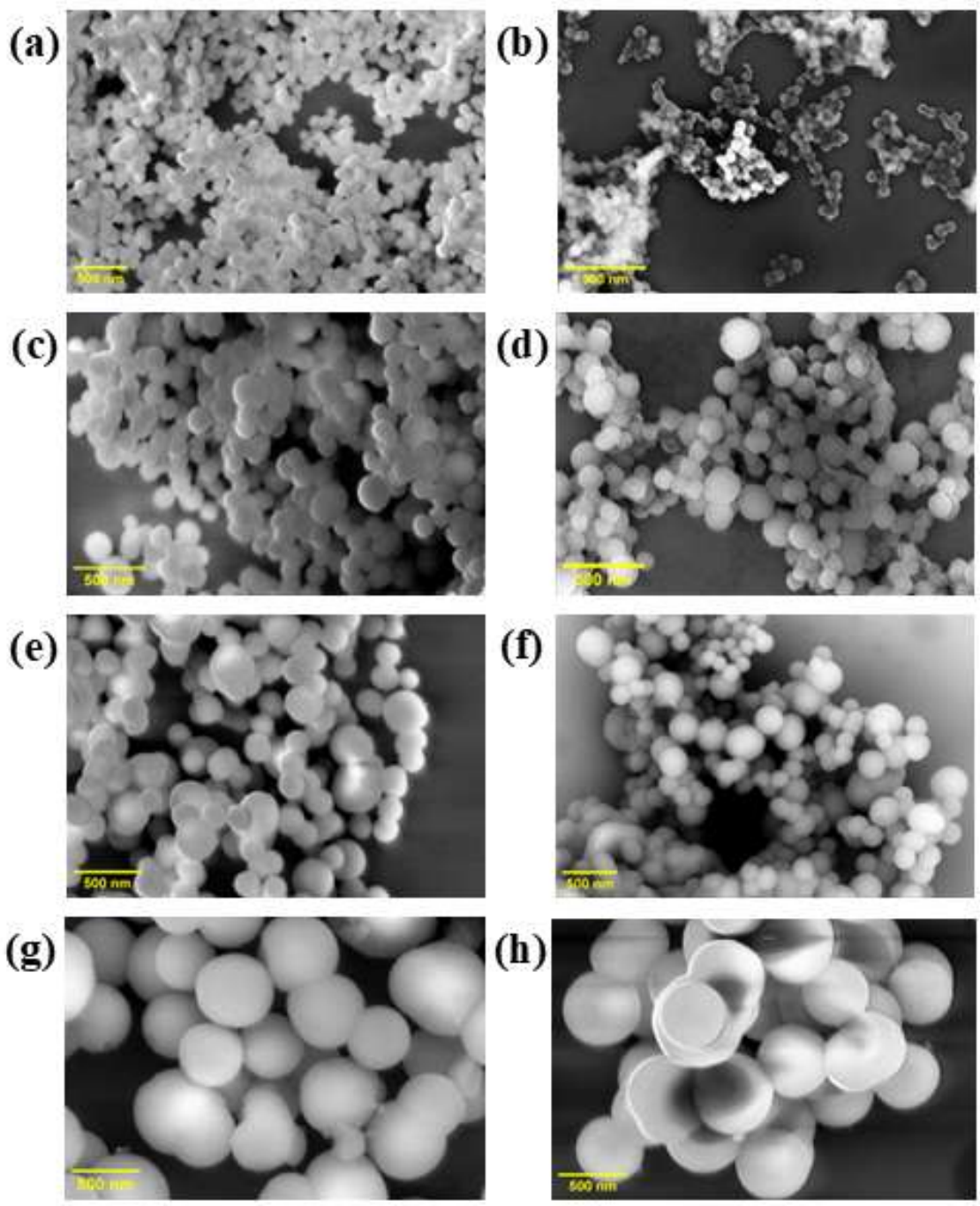
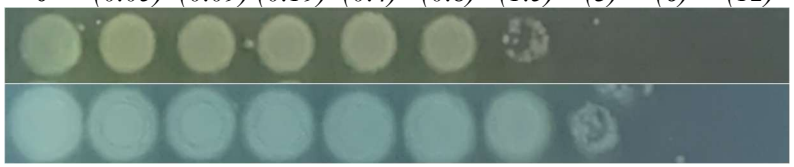
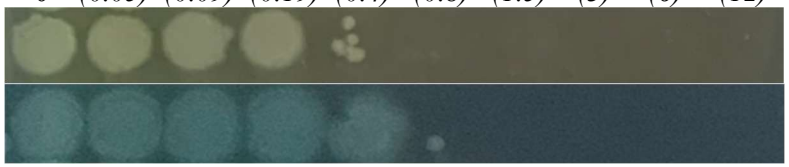
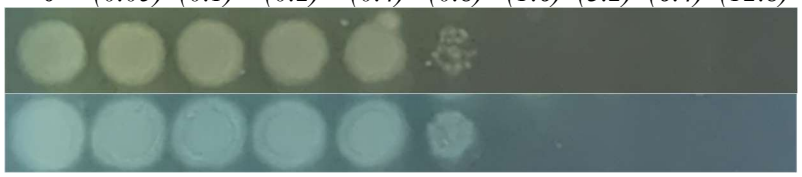
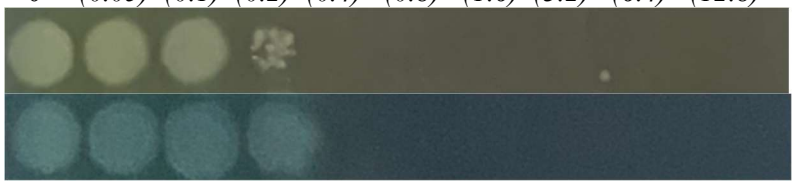
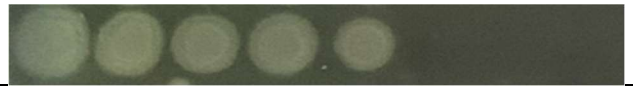
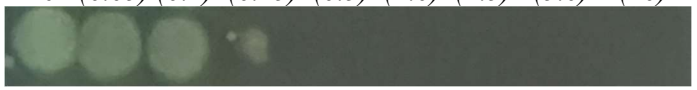


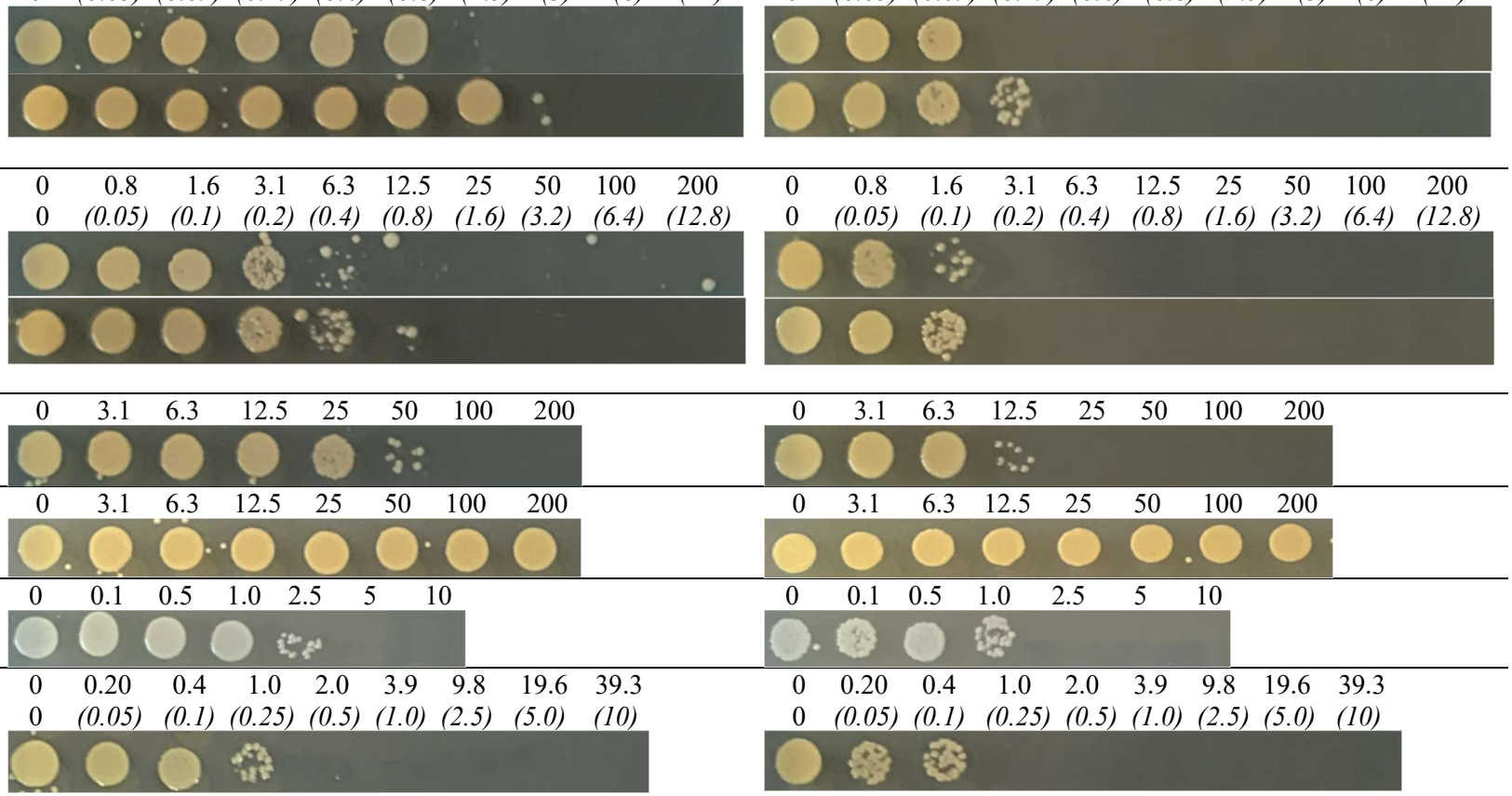
Figure S3. Scanning electron microscopy images of SiO_2 (a) and calcined SiO_2 (b); $[Cu(NH_3)_4]^{2+}$@SiO_2 (1.5%) (c) and Cu_xO@SiO_2 (1.5%) (d); $[Cu(NH_3)_4]^{2+}$@SiO_2 (3%) (e) and Cu_xO@SiO_2 (3%) (f); and $[Cu(NH_3)_4]^{2+}$@SiO_2 (5.5%) (g) and Cu_xO@SiO_2 (5.5%) (h). Scale bars = 500 nm.

Table S1. Colony-forming ability of bacteria and yeast after 4-h and 24-h exposure to nanocomposites and respective positive controls (CTAB and $CuSO_4 \cdot 5H_2O$) to bacteria and yeast in deionized water at 30°C. After exposure, cells (3 µL) were transferred onto toxicant-free agarized growth medium. All experiments were performed in at least three independent replicates; images shown are representative.

Compound or material	***E. coli* ATCC 25922: 4-h** **Concentrations: µg compound/mL *(µg Cu/mL)***	***E. coli* ATCC 25922: 24-h** **Concentrations: µg compound/mL *(µg Cu/mL)***
$[Cu(NH_3)_4]^{2+}@SiO_2$ (5.5%)	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.09)* *(0.19)* *(0.4)* *(0.8)* *(1.5)* *(3)* *(6)* *(12)*	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.09)* *(0.19)* *(0.4)* *(0.8)* *(1.5)* *(3)* *(6)* *(12)*
$[Cu(NH_3)_4]^{2+}@SiO_2$ (5.5%) 24h leached		
$Cu_xO@SiO_2$ (5.5%)	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.1)* *(0.2)* *(0.4)* *(0.8)* *(1.6)* *(3.2)* *(6.4)* *(12.8)*	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.1)* *(0.2)* *(0.4)* *(0.8)* *(1.6)* *(3.2)* *(6.4)* *(12.8)*
$Cu_xO@SiO_2$ (5.5%) 24h leached		
SiO_2, as prepared	0 3.1 6.3 12.5 25 50 100 200	0 3.1 6.3 12.5 25 50 100 200
SiO_2, calcined	0 3.1 6.3 12.5 25 50 100 200	0 3.1 6.3 12.5 25 50 100 200
CTAB	0 0.1 0.5 1.0 2.5 5 10	0 0.1 0.5 1.0 2.5 5 10
$CuSO_4 \cdot 5H_2O$	0 0.20 0.4 1.0 2.0 3.9 9.8 19.6 39.3 0 *(0.05)* *(0.1)* *(0.25)* *(0.5)* *(1.0)* *(2.5)* *(5.0)* *(10)*	0 0.20 0.4 1.0 2.0 3.9 9.8 19.6 39.3 0 *(0.05)* *(0.1)* *(0.25)* *(0.5)* *(1.0)* *(2.5)* *(5.0)* *(10)*

Compound or material	*P. aeruginosa* ATCC 27853: 4-h Concentrations: µg compound/mL *(µg Cu/mL)*	*P. aeruginosa* ATCC 27853: 24-h Concentrations: µg compound/mL *(µg Cu/mL)*
$[Cu(NH_3)_4]^{2+}@SiO_2$ (5.5%)	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.09)* *(0.19)* *(0.4)* *(0.8)* *(1.5)* *(3)* *(6)* *(12)*	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.09)* *(0.19)* *(0.4)* *(0.8)* *(1.5)* *(3)* *(6)* *(12)*
$[Cu(NH_3)_4]^{2+}@SiO_2$ (5.5%) 24h leached		
$Cu_xO@SiO_2$ (5.5%)	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.1)* *(0.2)* *(0.4)* *(0.8)* *(1.6)* *(3.2)* *(6.4)* *(12.8)*	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.1)* *(0.2)* *(0.4)* *(0.8)* *(1.6)* *(3.2)* *(6.4)* *(12.8)*
$Cu_xO@SiO_2$ (5.5%) 24h leached		
SiO_2, as prepared	0 3.1 6.3 12.5 25 50 100 200	0 3.1 6.3 12.5 25 50 100 200
		
SiO_2, calcined	0 3.1 6.3 12.5 25 50 100 200	0 3.1 6.3 12.5 25 50 100 200
		
CTAB	0 0.1 0.5 1.0 2.5 5 10	0 0.1 0.5 1.0 2.5 5 10
		
$CuSO_4 \cdot 5H_2O$	0 0.20 0.4 1.0 2.0 3.9 9.8 19.6 39.3 0 *(0.05)* *(0.1)* *(0.25)* *(0.5)* *(1.0)* *(2.5)* *(5.0)* *(10)*	0 0.20 0.4 1.0 2.0 3.9 9.8 19.6 39.3 0 *(0.05)* *(0.1)* *(0.25)* *(0.5)* *(1.0)* *(2.5)* *(5.0)* *(10)*
		

Compound or material	***S. aureus* ATCC 6538: 4-h** **Concentrations: µg compound/mL *(µg Cu/mL)***	***S. aureus* ATCC 6538: 24-h** **Concentrations: µg compound/mL *(µg Cu/mL)***
$[Cu(NH_3)_4]^{2+}@SiO_2$ (5.5%) $[Cu(NH_3)_4]^{2+}@SiO_2$ (5.5%) 24h leached	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.09)* *(0.19)* *(0.4)* *(0.8)* *(1.5)* *(3)* *(6)* *(12)*	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.09)* *(0.19)* *(0.4)* *(0.8)* *(1.5)* *(3)* *(6)* *(12)*
$Cu_xO@SiO_2$ (5.5%) $Cu_xO@SiO_2$ (5.5%) 24h leached	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.1)* *(0.2)* *(0.4)* *(0.8)* *(1.6)* *(3.2)* *(6.4)* *(12.8)*	0 0.8 1.6 3.1 6.3 12.5 25 50 100 200 0 *(0.05)* *(0.1)* *(0.2)* *(0.4)* *(0.8)* *(1.6)* *(3.2)* *(6.4)* *(12.8)*
SiO_2, as prepared	0 3.1 6.3 12.5 25 50 100 200	0 3.1 6.3 12.5 25 50 100 200
SiO_2, calcined	0 3.1 6.3 12.5 25 50 100 200	0 3.1 6.3 12.5 25 50 100 200
CTAB	0 0.1 0.5 1.0 2.5 5 10	0 0.1 0.5 1.0 2.5 5 10
$CuSO_4 \cdot 5H_2O$	0 0.20 0.4 1.0 2.0 3.9 9.8 19.6 39.3 0 *(0.05)* *(0.1)* *(0.25)* *(0.5)* *(1.0)* *(2.5)* *(5.0)* *(10)*	0 0.20 0.4 1.0 2.0 3.9 9.8 19.6 39.3 0 *(0.05)* *(0.1)* *(0.25)* *(0.5)* *(1.0)* *(2.5)* *(5.0)* *(10)*



Compound or material	*C. albicans* ATCC 10231: 4-h Concentrations: µg compound/mL *(µg Cu/mL)*	*C. albicans* ATCC 10231: 24-h Concentrations: µg compound/mL *(µg Cu/mL)*
$[Cu(NH_3)_4]^{2+}$@SiO_2 (5.5%)	0 7.8 15.6 31.3 62.5 125 250 500 0 *(0.5)* *(0.9)* *(1.8)* *(3.6)* *(7.3)* *(15)* *(29)*	0 7.8 15.6 31.3 62.5 125 250 500 0 *(0.5)* *(0.9)* *(1.8)* *(3.6)* *(7.3)* *(15)* *(29)*
Cu_xO@SiO_2 (5.5%)	0 7.8 15.6 31.3 62.5 125 250 500 0 *(0.5)* *(0.9)* *(1.9)* *(3.8)* *(7.5)* *(15)* *(30)*	0 7.8 15.6 31.3 62.5 125 250 500 0 *(0.5)* *(0.9)* *(1.9)* *(3.8)* *(7.5)* *(15)* *(30)*
SiO_2, as prepared	0 7.8 15.6 31.3 62.5 125 250 500	0 7.8 15.6 31.3 62.5 125 250 500
SiO_2, calcined	0 7.8 15.6 31.3 62.5 125 250 500	0 7.8 15.6 31.3 62.5 125 250 500
CTAB	0 3.9 7.8 15.6 31.3 62.5 125 250	0 3.9 7.8 15.6 31.3 62.5 125 250
$CuSO_4 \cdot 5H_2O$	0 2.5 4.9 9.8 20 39 79 157 0 (0.6) (1.3) (2.5) (5) (10) (20) (40)	0 2.5 4.9 9.8 20 39 79 157 0 (0.6) (1.3) (2.5) (5) (10) (20) (40)

Compound or material	*C. auris* ATCC MYA 5001: 4-h Concentrations: µg compound/mL *(µg Cu/mL)*	*C. auris* ATCC MYA 5001: 24-h Concentrations: µg compound/mL *(µg Cu/mL)*
$[Cu(NH_3)_4]^{2+}@SiO_2$ (5.5%)	0 7.8 15.6 31.3 62.5 125 250 500 0 *(0.5)* *(0.9)* *(1.8)* *(3.6)* *(7.3)* *(15)* *(29)* 	0 7.8 15.6 31.3 62.5 125 250 500 0 *(0.5)* *(0.9)* *(1.8)* *(3.6)* *(7.3)* *(15)* *(29)* 
$Cu_xO@SiO_2$ (5.5%)	0 7.8 15.6 31.3 62.5 125 250 500 0 *(0.5)* *(0.9)* *(1.9)* *(3.8)* *(7.5)* *(15)* *(30)* 	0 7.8 15.6 31.3 62.5 125 250 500 0 *(0.5)* *(0.9)* *(1.9)* *(3.8)* *(7.5)* *(15)* *(30)* 
SiO_2, as prepared	0 7.8 15.6 31.3 62.5 125 250 500 	0 7.8 15.6 31.3 62.5 125 250 500 
SiO_2, calcined	0 7.8 15.6 31.3 62.5 125 250 500 	0 7.8 15.6 31.3 62.5 125 250 500 
CTAB	0 1.0 1.95 3.9 7.8 15.6 31.3 62.5 	0 1.0 1.95 3.9 7.8 15.6 31.3 62.5 
$CuSO_4 \cdot 5H_2O$	0 2.5 4.9 9.8 20 39 79 157 0 (0.6) (1.3) (2.5) (5) (10) (20) (40) 	0 2.5 4.9 9.8 20 39 79 157 0 (0.6) (1.3) (2.5) (5) (10) (20) (40)