Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.
This journal is © The Royal Society of Chemistry 2023

Exploration of 3D NiCu-layered double hydroxide flowers tailored on biomass-derived N-doped carbon stick electrode as a binder-less enzyme-free urea sensing probe

Ameer Farithkhan[a], N. S. K. Gowthaman[b], Hong Ngee Lim[c,*] and S. Meenakshi[a,*]

[a]Department of Chemistry, The Gandhigram Rural Institute-Deemed to be University, Gandhigram 624 302, Tamil Nadu, India

[b]School of Engineering, Monash University, Bandar Sunway, Selangor 47500, Malaysia

[c]Department of Chemistry, Faculty of Science, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

* Corresponding Authors:

H.N. Lim, Email: hongngee@upm.edu.my, Tel.: +60 163301609

S. Meenakshi, Email: sankaranmeenakshi2014@gmail.com, Tel.: +91 9443838121

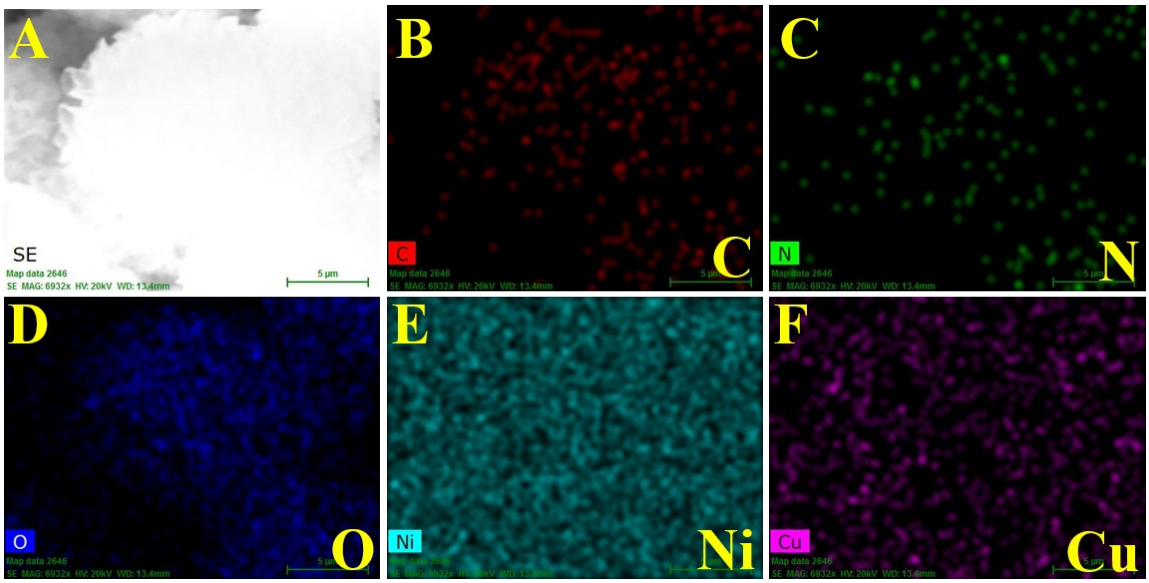

Fig. S1. (A) SEM image of NC-87 and its elemental mapping of (B) C, (C) N, (D) O, (E) Ni and (F) Cu.

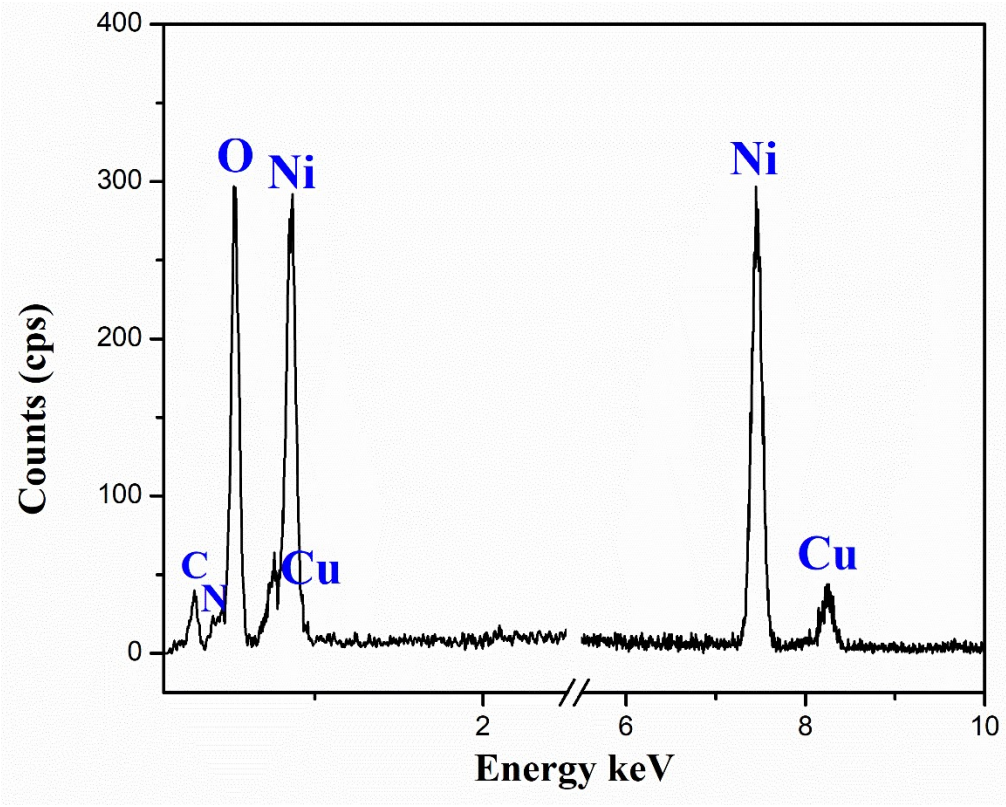

Fig. S2. EDAX patterns of NC-87 sensor.

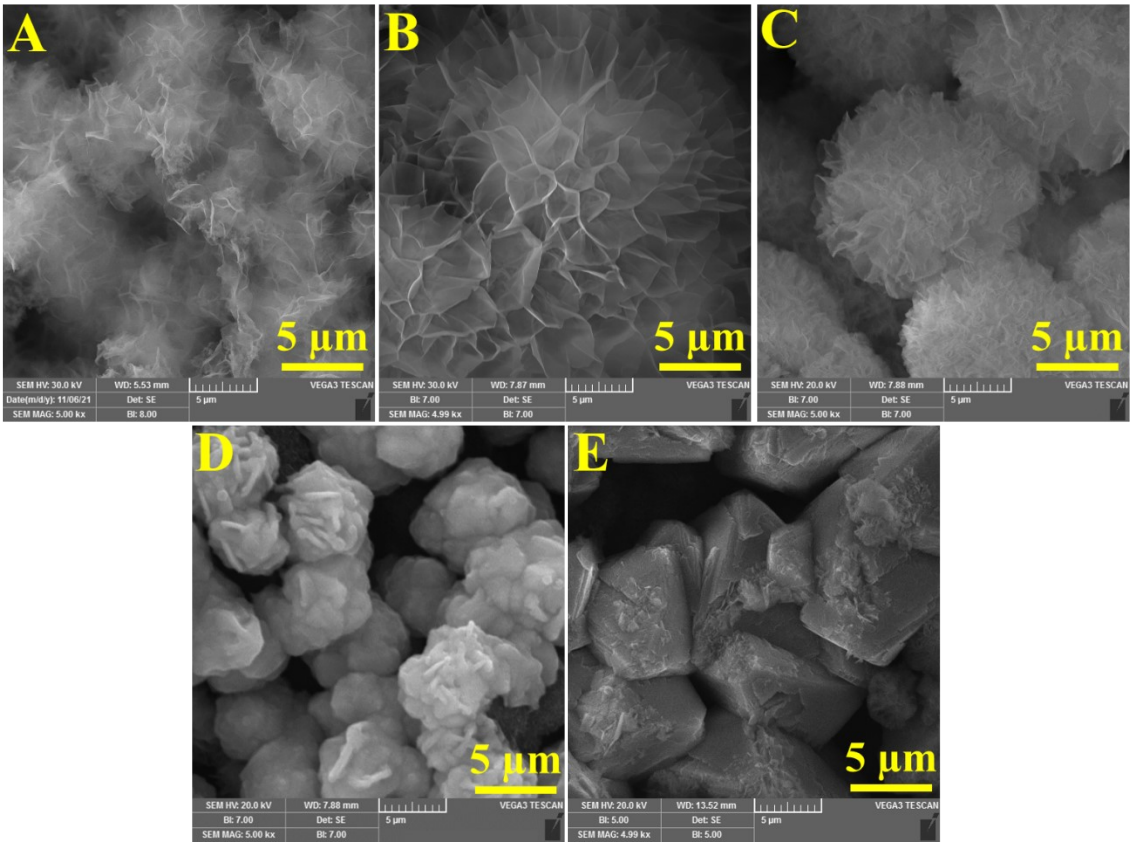

Fig. S3. SEM images of (A) NC-100, (B) NC-87, (C) NC-75, (D) NC-50 and (E) NC-0.

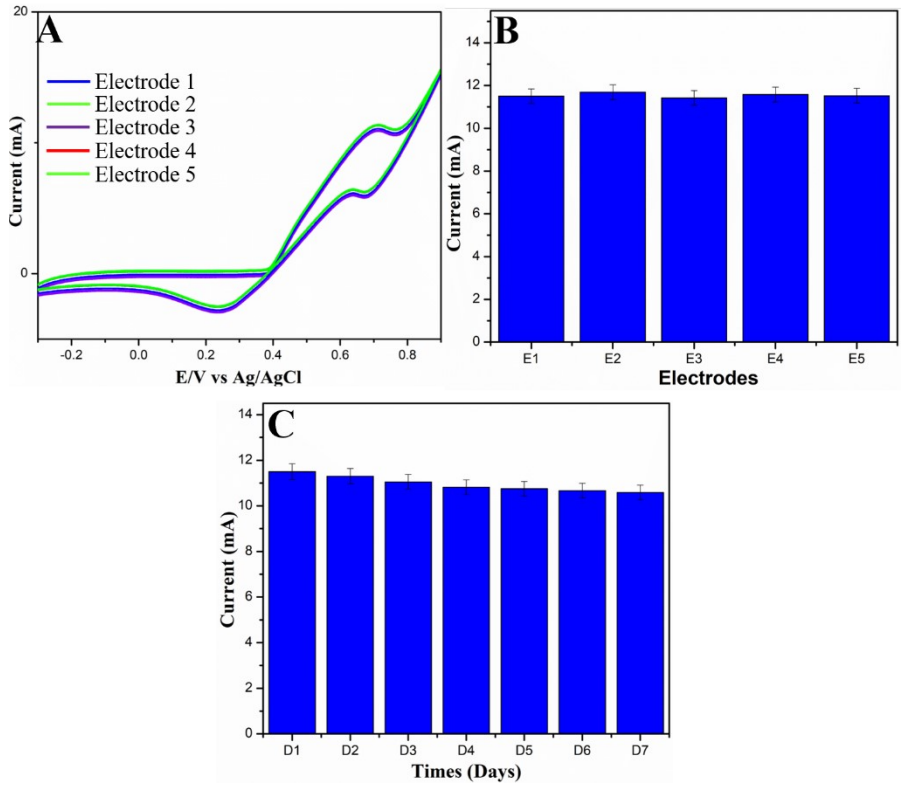

Fig. S4. Reproducibility (A, B) and stability (C) of NC-87 electrodes in 0.1 M KOH containing 2 mM urea at a scan rate of 50 mV s^{-1}.

Table S1. Comparison of the performance of NF-87 electrode towards urea sensing with the reported papers

Sensor Materials	**Type**	**Linear range (mM)**	**LOD[A] (mM)**	**Sensitivity**	**Ref.**
Gr[a]-PANI[b]/GCE[c]	Enzyme-free	0.01-0.2	0.0059	226.9 μA μm^{-1} cm^{-2}	(1)
Urs[d]-PANi-nafion/Au	Urease	1-10	1	4.2 μA mM^{-1} cm^{-2}	(2)
PPy[e]/GCE	Enzyme-free	0.08-1.36	0.04	1.11 μA μM^{-1} cm^{-2}	(3)
SnO_2 film/Al sheet	Enzyme-free	1-20	0.6	18.9 μA mM^{-1}	(4)
PANi/CdS-QDs[f]/PDA[g]-Ni	Enzyme-free	0.1-10	0.047	-	(5)
AgNP[h]-deposited commercial Au–Pd	Enzyme-free	1-8	0.14	9.212 μA mM^{-1}	(6)
Urs-GLDH[i]/GOS[j]	Urease and glutamate	3.3-19.9	2.1	2.6 mA mM^{-1} cm^{-2}	(7)
NC-LDH@NCSE	Enzyme-free	0.02-5.0	0.033	21 mA mM^{-1} cm^{-2}	This

	work

[A]limit of detection; [a]graphene; [b]polyaniline; [c]glassy carbon electrode; [d]urease; [e]polypyrrole; [f]CdS-quantum dots; [g]Ni-2,3-pyrazine dicarboxylic acid; [h]nanoparticles; [i]glutamate dehydrogenase; [i]graphene oxide–SiO_2 composite electrode.

REFERENCES

(1) R. Sha, K. Komori, S. Badhulika, Graphene-polyaniline composite based ultra-sensitive electrochemical sensor for non-enzymatic detection of urea, *Electrochim. Acta,* 2017, **233**, 44-51.

(2) Y.C. Luo, J.S. Do, Urea biosensor based on PANI(urease)-Nafion®/Au composite electrode, *Biosens. Bioelectron,* 2004, **20**, 15-23.

(3) S. Mondal, M.V. Sangaranarayanan, A novel non-enzymatic sensor for urea using a ploypyrrole-coated platinum electrode, *Sens. Actuators B Chem*., 2013, **177**, 478-486.

(4) S.G. Ansari, H. Fouad, H.S. Shin, Z-A. Ansari, Z-A, Electrochemical enzyme-less urea sensor based on nano-tin oxide synthesized by hydrothermal technique, *Chem. Biol. Interact*., 2015, **242**, 45-49.

(5) A. Azadbakht, M.B. Gholivand, Covalent attachment of Ni-2,3-pyrazine dicarboxylic acid onto gold nanoparticle gold electrode modified with penicillamine- CdS quantum dots for electrocatalytic oxidation and determination of urea, *Electrochim. Acta,* 2014, **124**, 9-21.

(6) J. Liu, R.S. Moakhar, A.S. Perumal, H.N. Roman, S. Mahshid, S. Wachsmann-Hogiu, An AgNP-deposited commercial electrochemistry test strip as a platform for urea detection, *Sci. Rep.,* 2020, **10**, 9527-9538.

(7) S. Abraham, V. Ciobota, S. Srivastava, S.K. Srivastava, R.K. Singh, J. Dellith, B.D. Malhotra, M. Schmitt, J. Popp, A. Srivastava, Mesoporous silica particle embedded functional graphene oxide as an efficient platform for urea biosensing, *Anal. Methods*, 2014, **6**, 6711-6721.