Electronic Supplementary Material (ESI) for Analytical Methods.

Supporting Information

Flexible paper-based label-free electrochemical biosensor for monitoring miRNA-21 using core-shell Ag@Au/GQDs nano-ink

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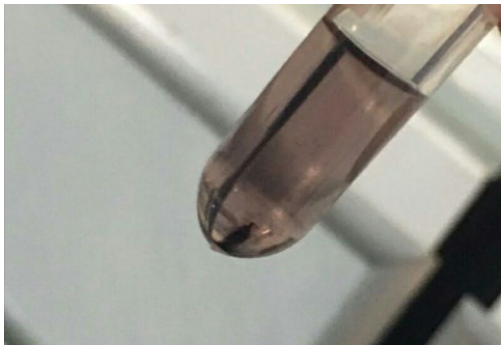
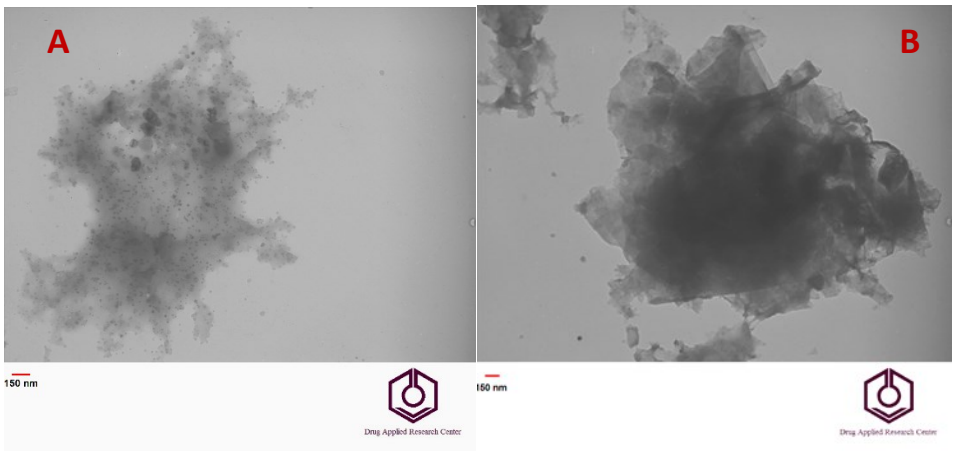
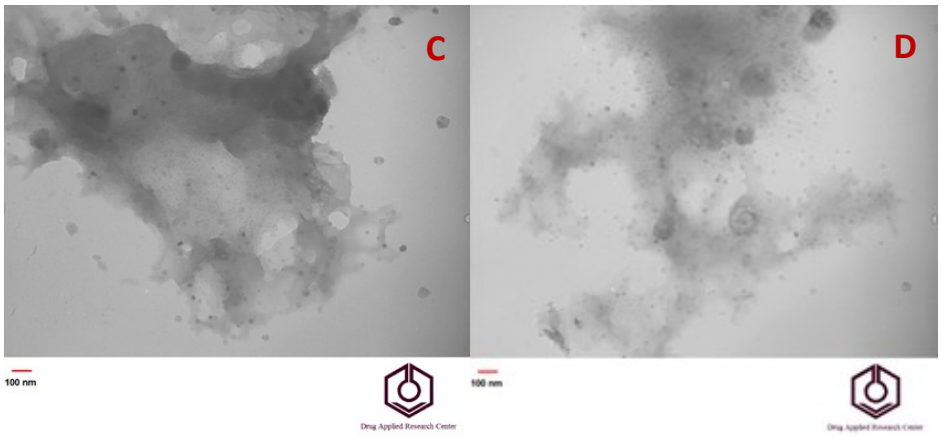


Fig. S1. Photographic image of Ag@Au core-shell NPs after centrifugation.


A
150 nm
Drug Applied Research Center
B
150 nm
Drug Applied Research Center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D
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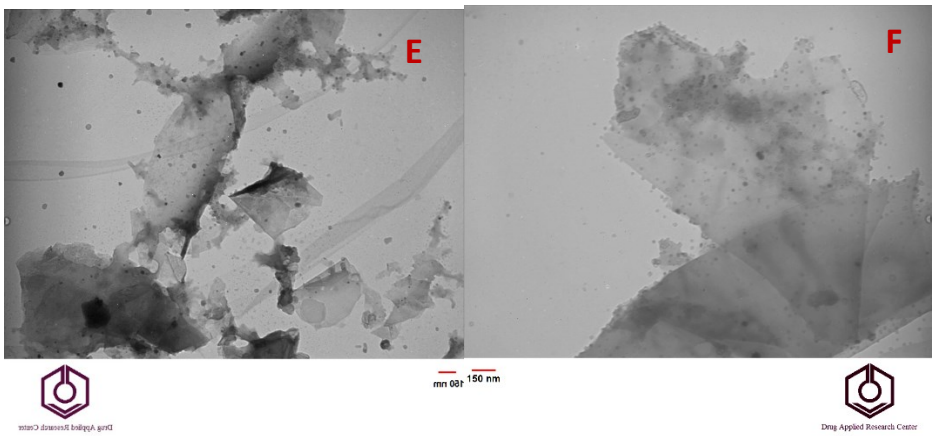

E
150 nm
F
150 nm
Drug Applied Research Center

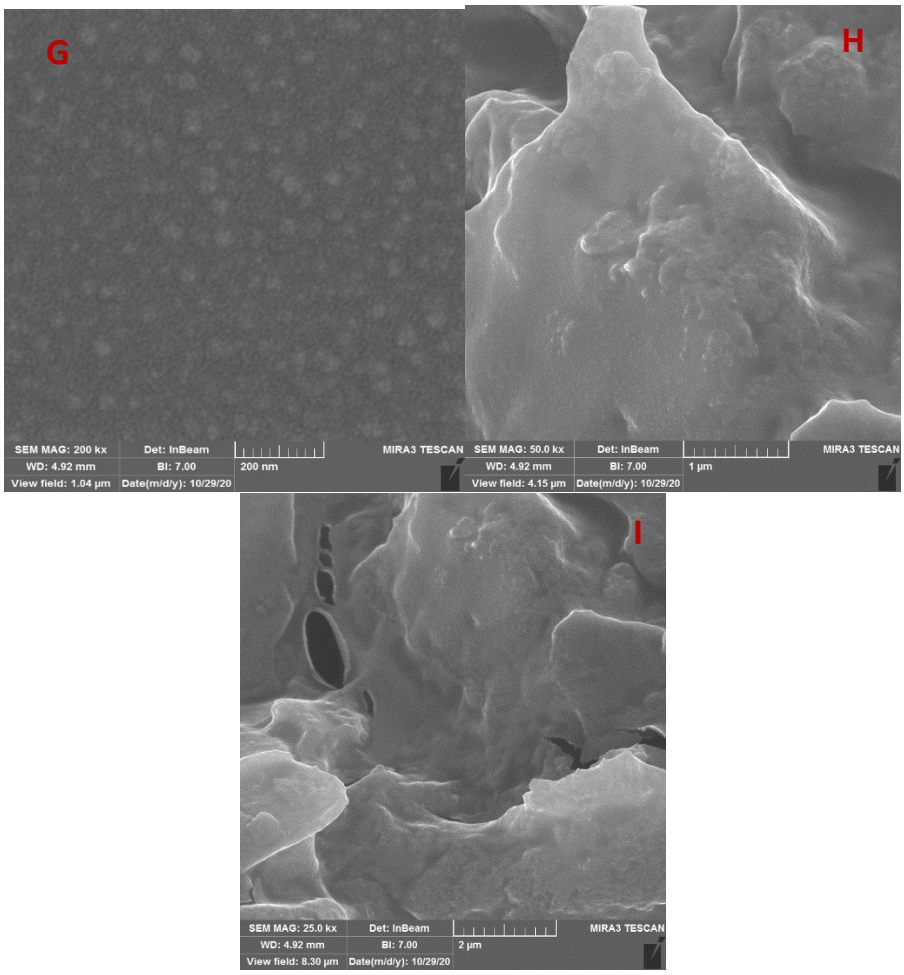
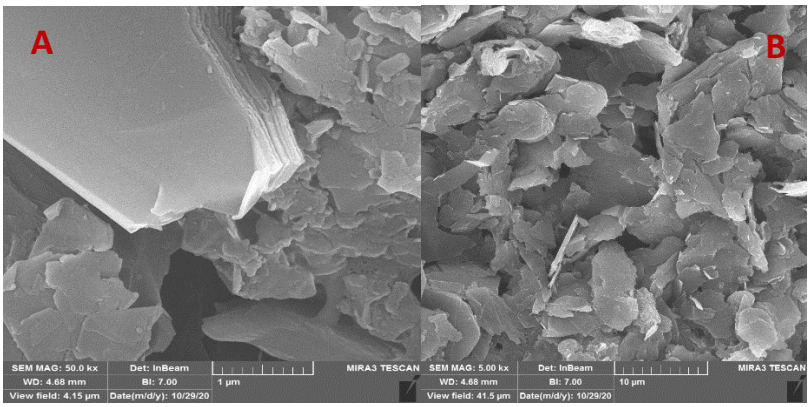
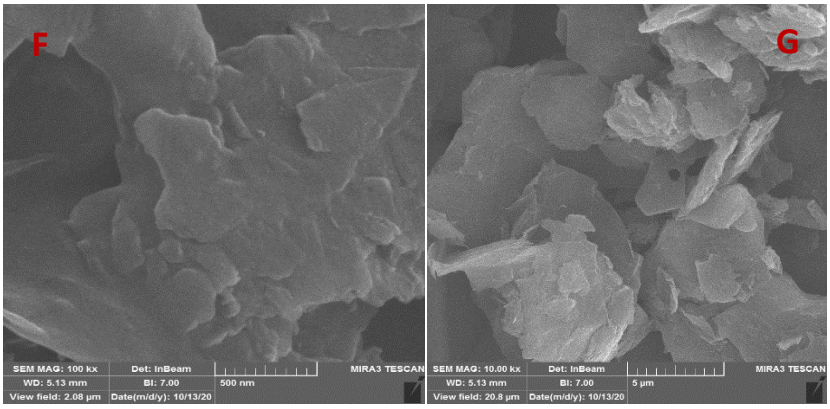
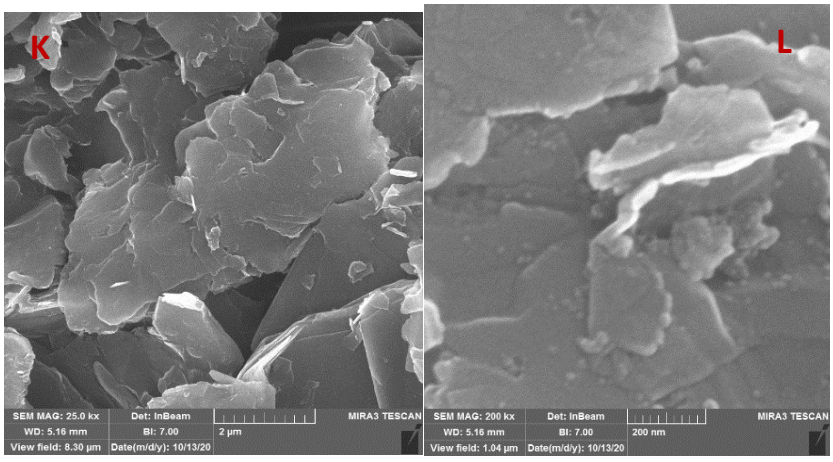


Fig. S2. A-F) TEM images of prepared Ag@Au core-shell/GQDs nano-ink, **G-I)** FE-SEM images of prepared nano-ink in different exaggerations.


A
SEM MAG: 50.0 kx
Det: InBeam
MIRA3 TESCAN
WD: 4.68 mm
BI: 7.00
1 µm
View field: 4.15 µm
Date(m/d/y): 10/29/20
B
SEM MAG: 5.00 kx
Det: InBeam
MIRA3 TESCAN
WD: 4.68 mm
BI: 7.00
10 µm
View field: 41.5 µm
Date(m/d/y): 10/29/20


F
SEM MAG: 100 kx
Det: InBeam
MIRA3 TESCAN
WD: 5.13 mm
BI: 7.00
500 nm
View field: 2.08 µm
Date(m/d/y): 10/13/20
G
SEM MAG: 10.00 kx
Det: InBeam
MIRA3 TESCAN
WD: 5.13 mm
BI: 7.00
5 µm
View field: 20.8 µm
Date(m/d/y): 10/13/20


K
SEM MAG: 25.0 kx
Det: InBeam
MIRA3 TESCAN
WD: 5.16 mm
BI: 7.00
2 µm
View field: 8.30 µm
Date(m/d/y): 10/13/20
L
SEM MAG: 200 kx
Det: InBeam
MIRA3 TESCAN
WD: 5.16 mm
BI: 7.00
200 nm
View field: 1.04 µm
Date(m/d/y): 10/13/20

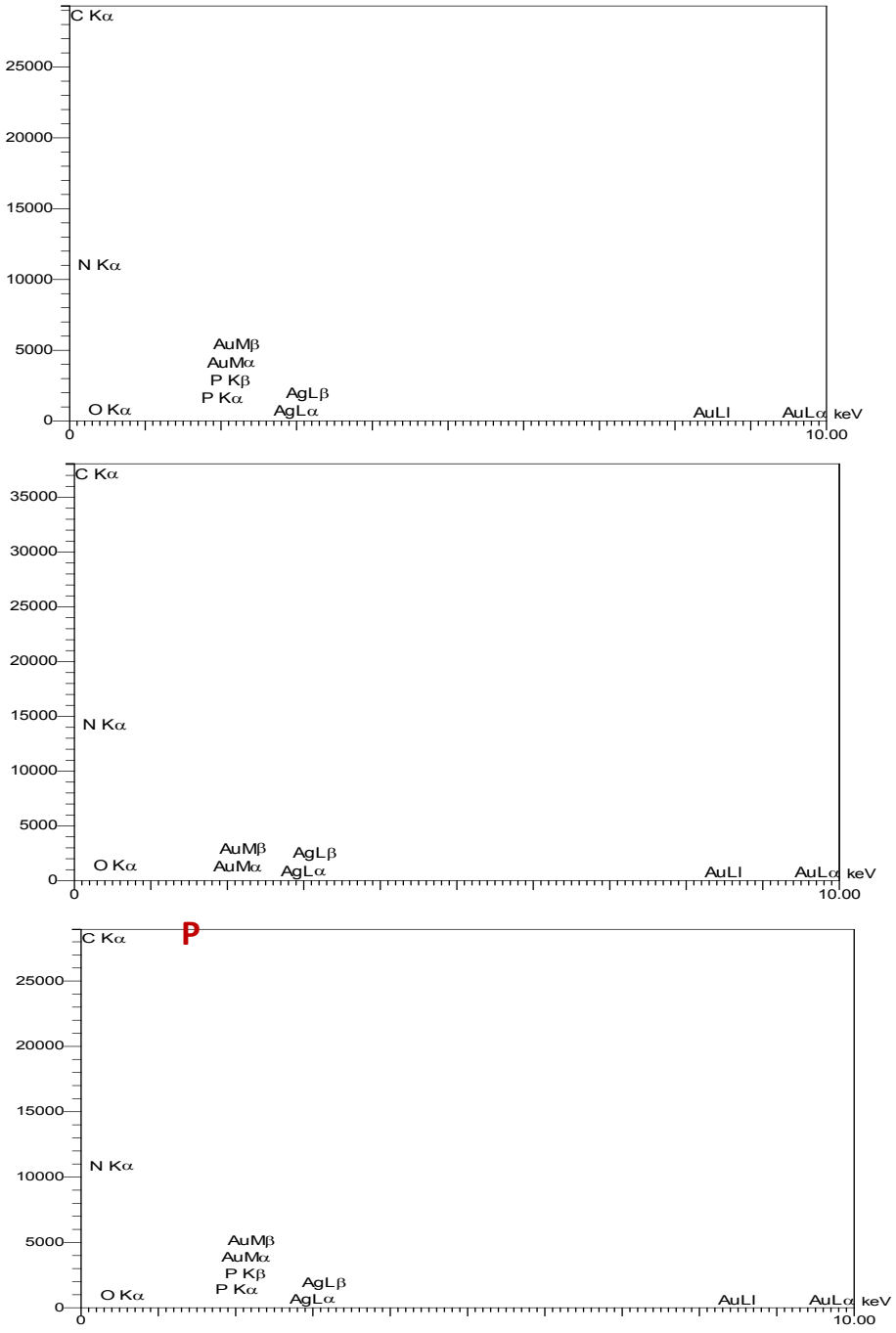


Fig.S3. (A-E) FE-SEM images of the Ag@Au core-shell/GQDs nano-ink on the surface of photographic paper. **(F-J)** FE-SEM images of the PNA-T9/Ag@Au core-shell/GQDs nano-ink on the surface of photographic paper, **(K-O)** FE-SEM images of the mi-RNA21/ MCE/ PNA-T9/Ag@Au core-shell/GQDs/ nano-ink on the surface of photographic paper **(P)** EDC images of the Ag@Au core-shell/GQDs nano-ink. **(Q)** EDC images of the PNA-T9/ Ag@Au core-shell/GQDs nano-ink, **(R)** EDC images of the mi-RNA21/PNA-T9/MCE/Ag@Au core-shell/GQDs nano-ink deposited on the surface of paper electrode.

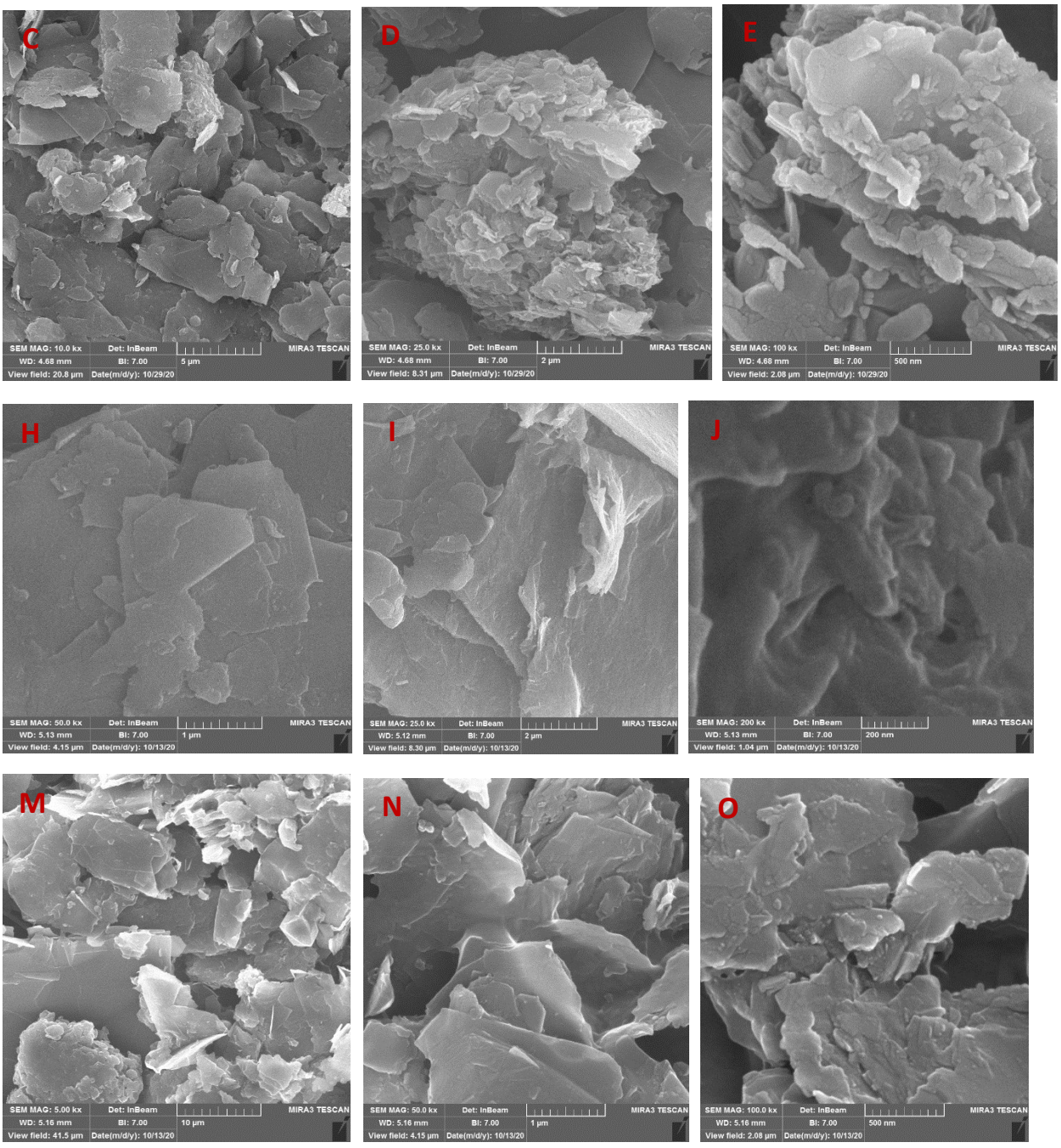


Fig. S4. (A-E) FE-SEM images of the Ag@Au core-shell/GQDs nano-ink on the surface of photographic paper. **(F-J)** FE-SEM images of the PNA-T9/Ag@Au core-shell/GQDs nano-ink on the surface of photographic paper, **(K-O)** FE-SEM images of the mi-RNA21/ MCE/ PNA-T9/Ag@Au core-shell/GQDs/ nano-ink on the surface of photographic paper.

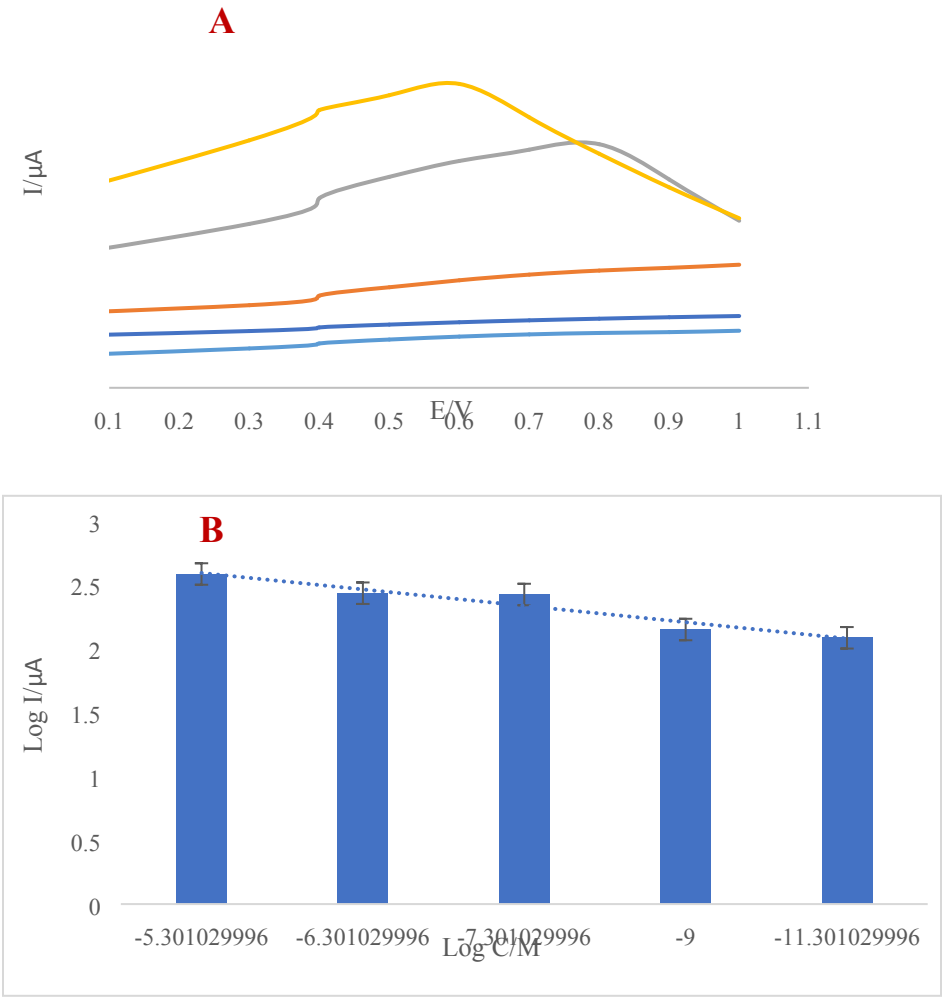
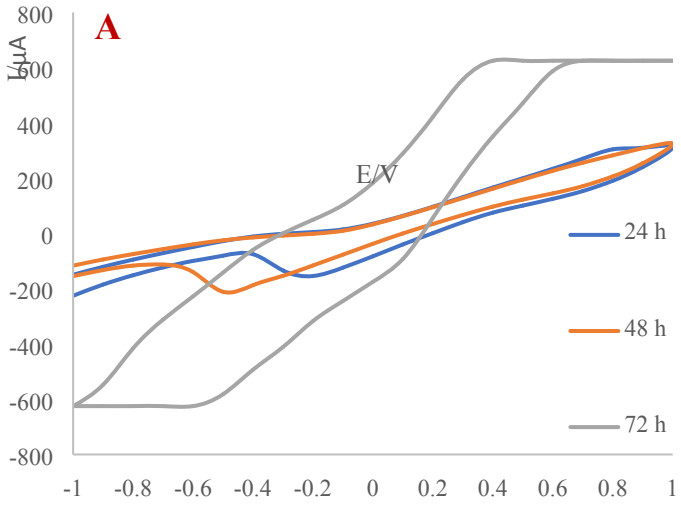
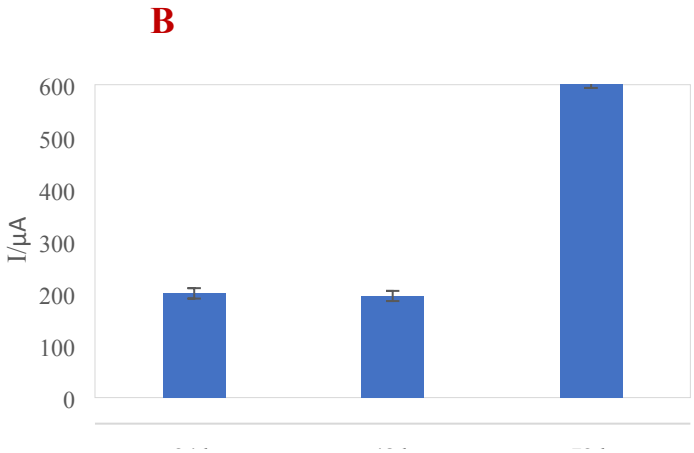
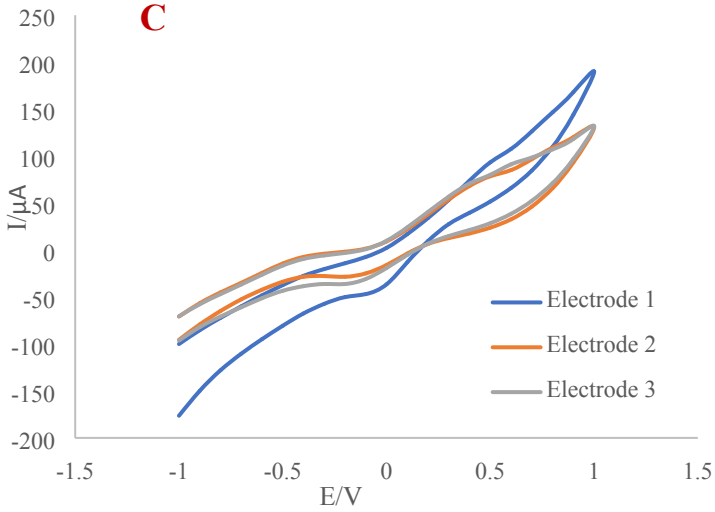


Fig. S5.A) SWVs (stop potential = 0.1 V, frequency = 1.0 Hz) of the engineered PNA-based biosensor for analysis of different concentrations of miRNA-21 in human plasma specimens**. B)** Calibration curves (n=5, SD=2.36).


A
800
600
400
200
0
-200
-400
-600
-800
I/μA
E/V
24 h
48 h
72 h
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0
0.4
0.6
0.8
1


B
600
500
400
300
200
100
0
I/μA


C
250
200
150
100
50
0
-50
-100
-150
-200
I/μA
-1.5
-1
-0.5
0
0.5
1
1.5
E/V
Electrode 1
Electrode 2
Electrode 3

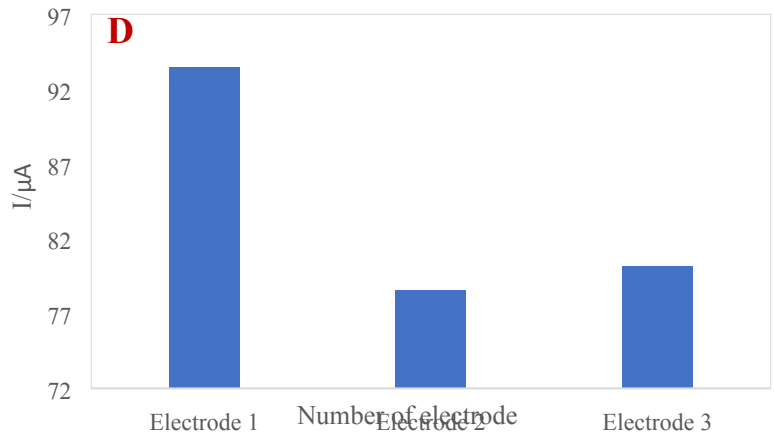


Fig. S6.A) CVs **B)** Histogram of intraday stability of PNA-T9/Ag@Au core-shell/GQDs nano-ink **C)** Inter-electrode reproducibility and **D)** Corresponding histogram chart of Ag@Au core-shell/GQDs nano-ink on the surface of photographic paper in 0.01M $[Fe(CN)_6]^{3-/4-}$/KCl solution as supporting electrolyte (Potential range= -1 to +1 V and scan rate= 10 mV/s). (n=3, SD=2.09).

Table. S1; Comparison of the performance and sensitivity of the designed biosensor for detecting of miRNA-21.

Detection method	Used materials	Linear area	LLOQ	Ref
Electrochemical (DPV)	three-dimensional (3D) DNA tetrahedron-structured probes (TSPs) and duplex-specific nuclease (DSN)	0.1 fM-0.1 pM	0.04 fM	34
Electrochemical (DPV)	hairpin H1 was hybridized with miR-21 in CHA and RCA	0.5-12 500 p.mol	290 f.mol	35
Amperometry (H_2O_2 -HQ)	AuNPs/SPCE	0.096-25 pM	29 fM	36
Smartphone-based electrochemical biosensing	reduced graphene oxide/gold (rGO/Au) composite	1×10^{-4} M-1×10^{-12} M	1×10^{-4} M	37
Florescence	nanosized graphene oxide (NGO)	10^{-14}-10^{-12} mol. L^{-1}	10^{-12} mol. L^{-1}	38
Fluorescence	Nano metal–organic framework (NMOF)	0- 1000 nM	10 pM	39
Electrochemical (ChA)	Ag@Au core-shell/GQDs nano-ink	5µM - 5pM	5pM	This work