Novel B,N-doped carbon quantum dots fluorescence quenching method for sensitive and green determination of lisinopril: Mechanistic insights from quantum calculations and sustainable analytical approach

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Table S1: Box-Behnken experimental design matrix showing the three-factor, three-level design for optimization of fluorescence quenching conditions.

		Factor 1	**Factor 2**	**Factor 3**
Std	Run	A:pH	B:B,N-doped CQDs Conc.	C:Reaction time
			μg/mL	min
16	1	6	60	6.5
17	2	6	60	6.5
7	3	3	60	10
8	4	9	60	10
10	5	6	90	3
1	6	3	30	6.5
14	7	6	60	6.5
12	8	6	90	10
5	9	3	60	3
3	10	3	90	6.5
13	11	6	60	6.5
9	12	6	30	3
6	13	9	60	3
2	14	9	30	6.5
15	15	6	60	6.5
4	16	9	90	6.5
11	17	6	30	10

Table S2: Statistical parameters for response surface model adequacy assessment including R^2, adjusted R^2, predicted R^2, and adequate precision values

Std. Dev.	0.1504	**R²**	0.9576
Mean	2.36	**Adjusted R²**	0.9383
C.V. %	6.37	**Predicted R²**	0.8429
		Adeq Precision	19.2989

Table S3: Recovery studies for lisinopril determination in spiked human plasma samples using the developed B,N-CQDs fluorescence method.

Spiked (µg/mL)	*Found (µg/mL)*	*Recovery (%)*	*RSD (n = 3, %)*
0.05	0.049	97.46	3.454
0.1	0.104	103.64	2.961
0.5	0.512	102.36	1.965
1.5	1.467	97.81	1.353

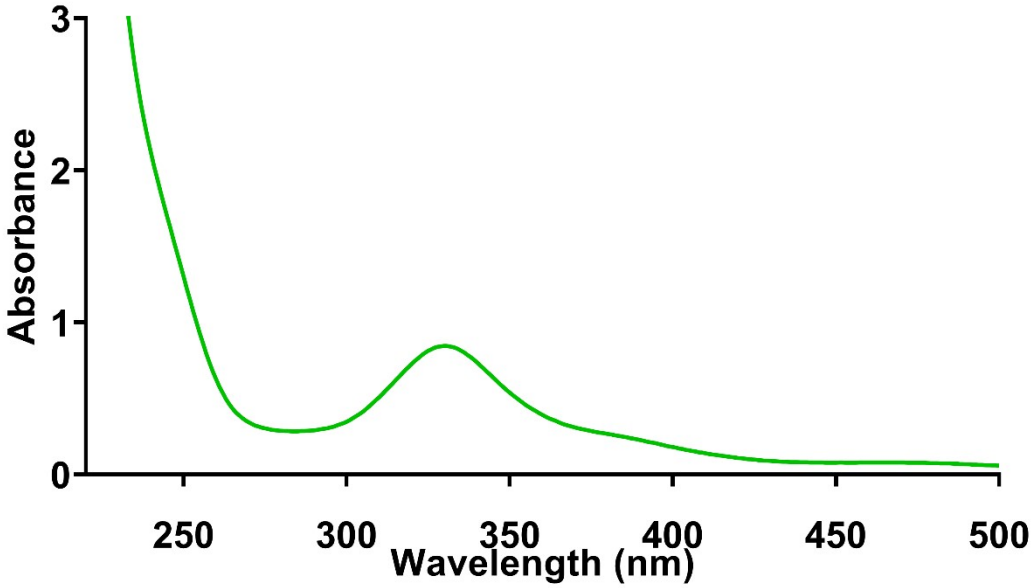

Fig. S1: UV-visible absorption spectrum of B,N-CQDs in aqueous solution showing strong absorption below 250 nm attributed to π-π* transitions and secondary absorption around 330 nm corresponding to n-π* transitions involving heteroatom doping effects.

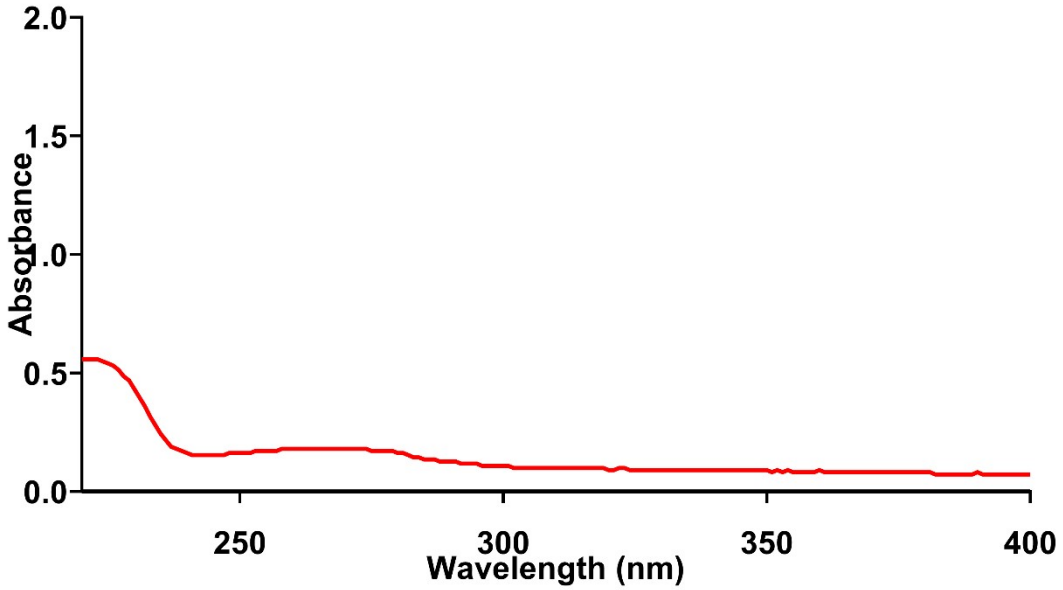

Fig. S2: UV-visible absorption spectrum of lisinopril (2.0 μg/mL) in aqueous solution demonstrating negligible absorption above 250 nm, effectively excluding inner filter effect as the primary quenching mechanism in the B,N-CQDs fluorescence sensing system.

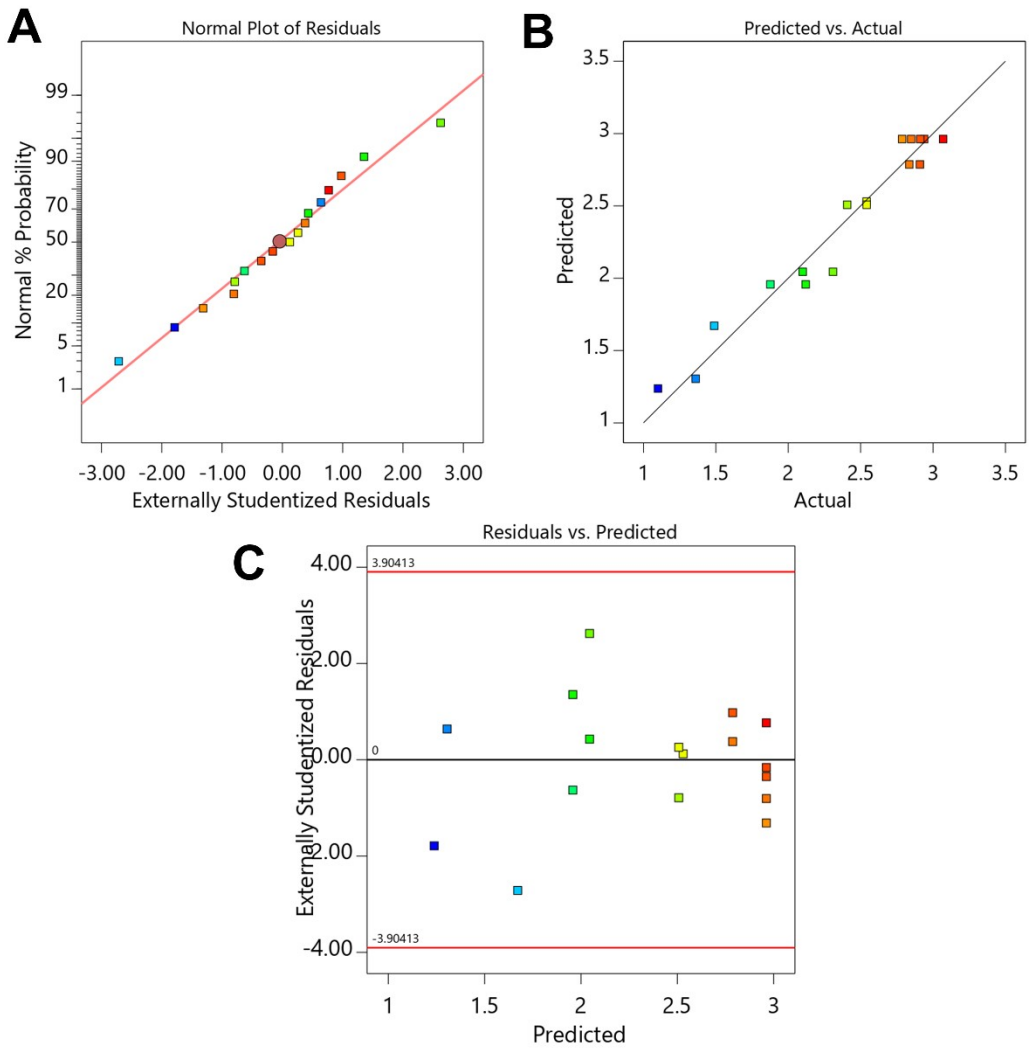

Fig. S3: Model adequacy diagnostic plots for Box-Behnken response surface methodology. (A) Normal probability plot of residuals demonstrating linear distribution along the diagonal line, confirming normality assumption. (B) Predicted versus actual values plot showing high correlation with points clustered around the diagonal line. (C) Residuals versus predicted values plot displaying random scatter without systematic patterns, validating homoscedasticity and model adequacy assumptions.

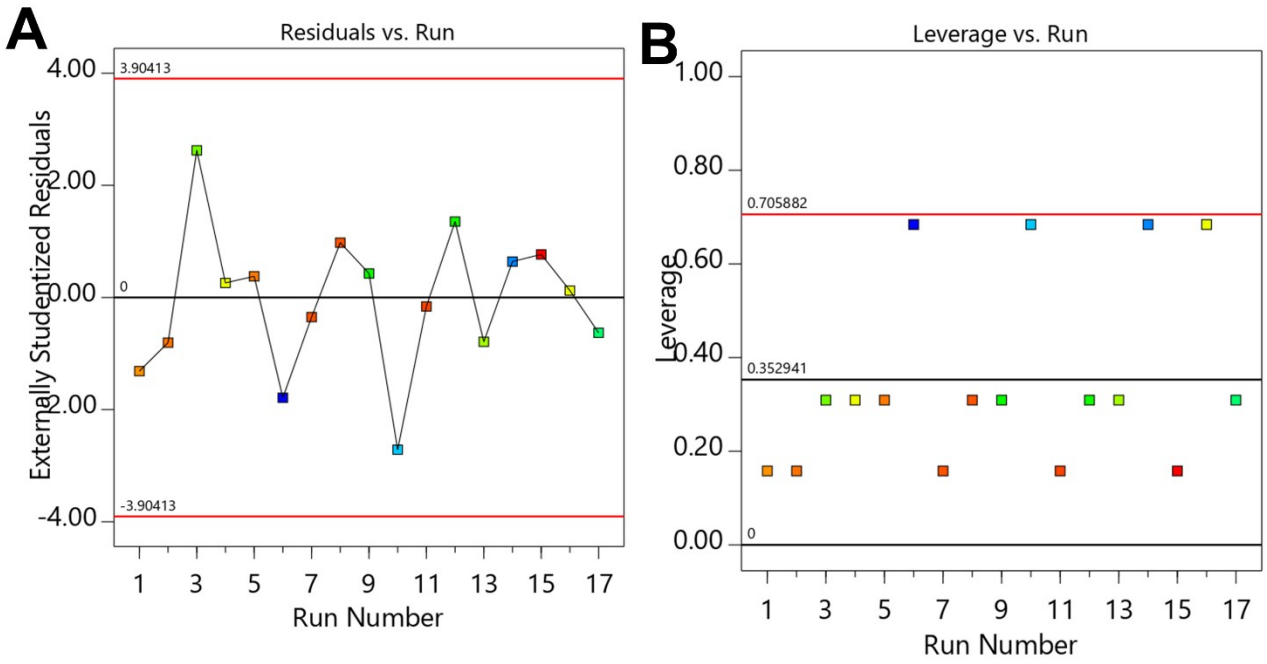

Fig. S4: Run order effect analysis for experimental design validation. (A) Externally studentized residuals versus run number showing random distribution across the experimental sequence with all points within ±3.90 limits, confirming absence of time-dependent effects such as instrument drift or reagent degradation. (B) Leverage versus run number demonstrating all experimental points below the critical threshold (0.706), indicating well-balanced experimental design without influential outliers affecting model parameters.

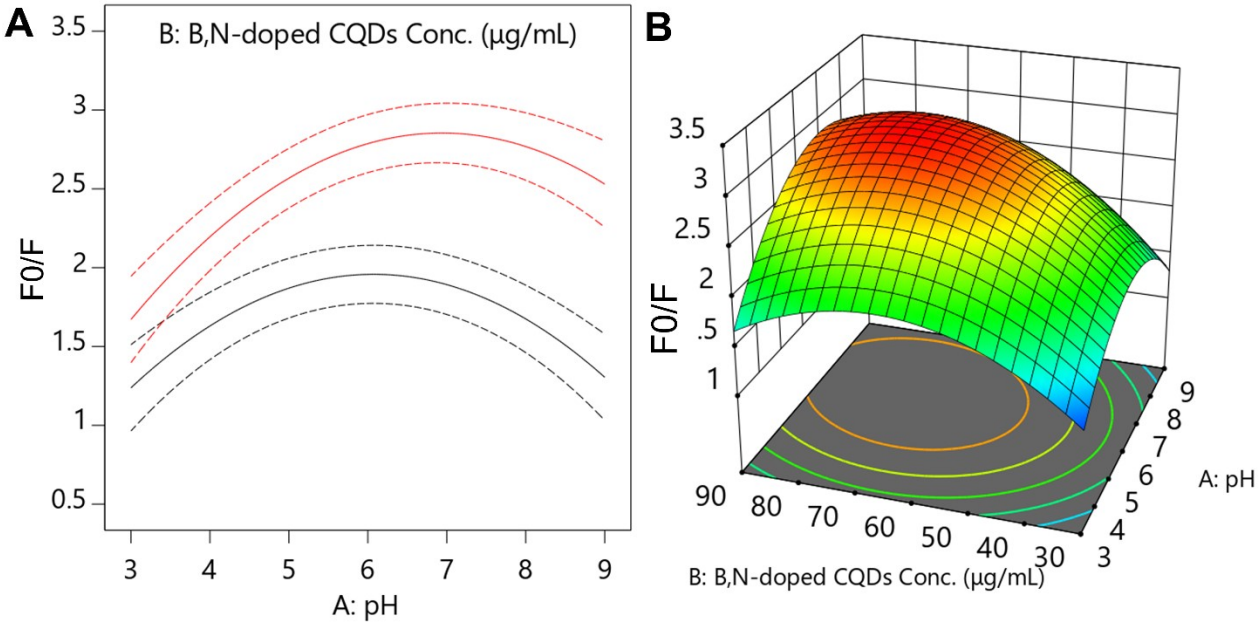

Fig. S5: Interaction and 3D response surface plots showing the combined effects of pH and B,N-CQDs concentration on quenching efficiency (F0/F). (A) Two-dimensional interaction plot demonstrating curved response lines at different B,N-CQDs concentrations, indicating synergistic effects between factors. (B) Three-dimensional response surface plot visualizing the response maximum as a distinct peak, confirming well-defined optimal conditions.

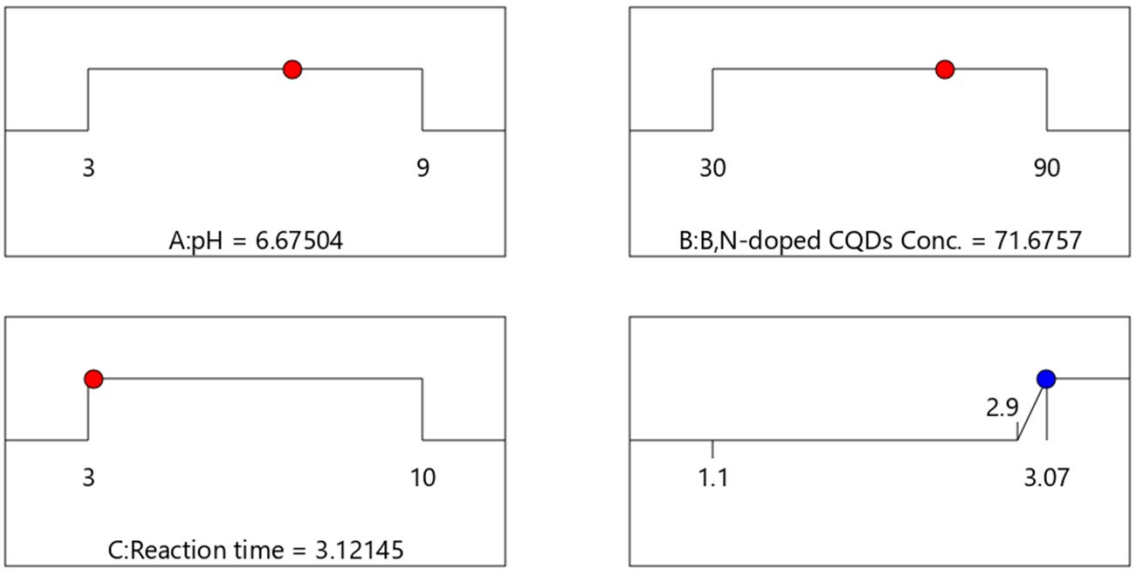

Fig. S6: Numerical optimization results using desirability function approach.

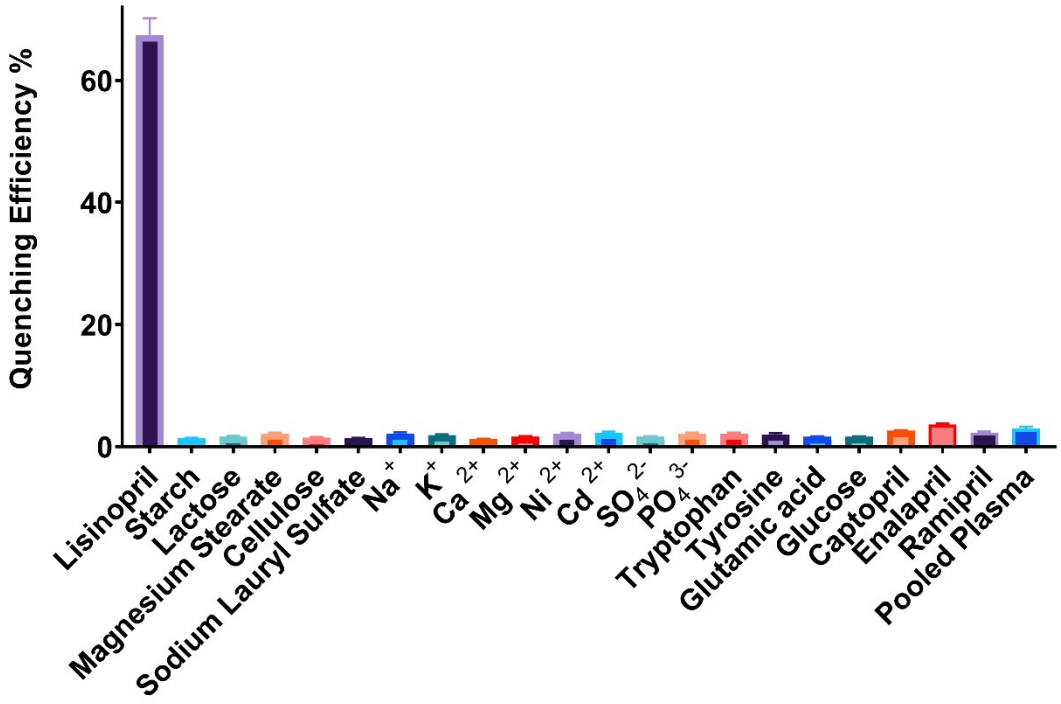

Fig. S7: Selectivity study showing the quenching efficiency (QE%) of lisinopril and potential interfering substances. Lisinopril (1 µg/mL) demonstrates high quenching efficiency (67%) while all tested interferents at 10-fold higher concentrations show negligible interference (<5% QE), confirming method selectivity.