Title

Next generation nano-biocatalysts: Extremozyme-based nanoparticle system for Cypermethrin bioremediation

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Table S1 Experimental range and level of the independent variables of selected components for RSM – CCD

Variable Code	Variable	+a	+1	0	-1	-a
A	Urea	3.11361	2.5	1.6	0.7	0.0863865
B	Cellulose	1.8409	1.5	1	0.5	0.159104
C	$MgSO_4$	0.18409	0.15	0.1	0.05	0.0159104

Table S2 Secondary Screening and Selection of Potential Isolates Based on Laccase Activity

Isolates	**pH**	**Enzyme Activity at pH 7 (U/ml)**	**Enzyme Activity at pH 9 (U/ml)**
JA1	6 and 7	0.015	0.005
JA2	6 and 7	0.011	0.023
JA3	6 and 7	0.073	0.063
JA5	6 and 7	0.086	0.075
JA6	6 and 7	0.098	0.078
JA7	6 and 7	0.011	0.001
JB1	**7 and 9**	**0.156**	**0.240**
JB2	7 and 9	0.080	0.042

JB3	7 and 9	0.015	0.166
JB4	7 and 9	0.009	0.012
JB5	7 and 9	0.007	0.080
JB6	7 and 9	0.153	0.226

Table S3a. Cypermethrin degradation quantification by FTIR and b. Cypermethrin degradation quantification by GC

a.

Sample	~3300 cm^{-1} (O–H/N–H)	~2090 cm^{-1} (C≡X)	~1640 cm^{-1} (C=C/C=O)	400–500 cm^{-1} (Halogen/M–O)	Unique/Notable Peaks	Degradation Inference
C (Cypermethrin)	3369.16	2091.64	1640.20	413.59, 746.30	Strong aromatic ring band	Baseline compound
B	3367.44	2099.32	1641.20	422.07	No aromatic ring peak	Possible ring modification
E	3369.31	2099.24	1641.84	454.03, 435.07	Shift in halogen band	Bond cleavage, halogen displacement
Se+BE	3372.89	-	1641.20	468.17, 439.40, 413.19	Multiple split peaks	Extensive degradation & metal interaction

b.

Sample	Major cypermethrin signal	Major observed by-products/peaks (RT & approximate area)	Interpretation
Control (EthylAcetate)	Cypermethrin peaks at RT 25.045 (1,140,603); 25.197 (873,797); 25.290 (838,751); 25.350 (667,939). Total ≈ 3,521,090	Heneicosane, Eicosane, Dodecane derivatives	Parent present — baseline.
SE+BE	No parent detected (cypermethrin absent)	2,4-Di-tert-butylphenol (RT ~12.56; area ≈ 563,400), various alkanes (heneicosane, etc.)	Advanced breakdown: oxidative product + hydrocarbons.
B	No parent detected	Dominant long-chain alkanes (several large peaks assigned to heneicosane; large summed area of hydrocarbon peaks)	Parent degraded; chromatogram dominated by matrix hydrocarbons.
E	No parent detected	2,4-Di-tert-butylphenol (RT ~12.56; area ≈ 1,268,733), hexadecane, dodecane derivatives	High phenolic intermediate signal — strong evidence of oxidative cleavage.

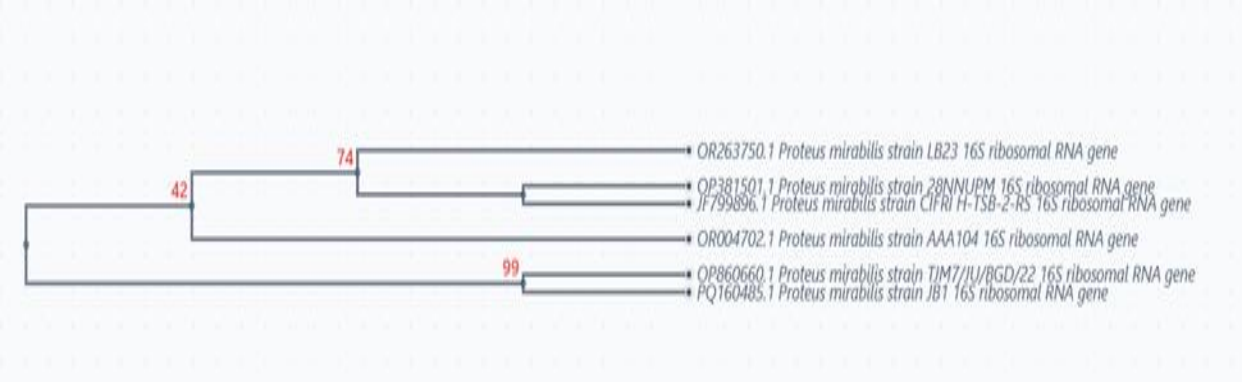


Figure S1: The Phylogenetic tree showing the relationship between isolated *Proteus mirabilis* JB1 (PQ160485) and other closely related sequences on NCBI GenBank.

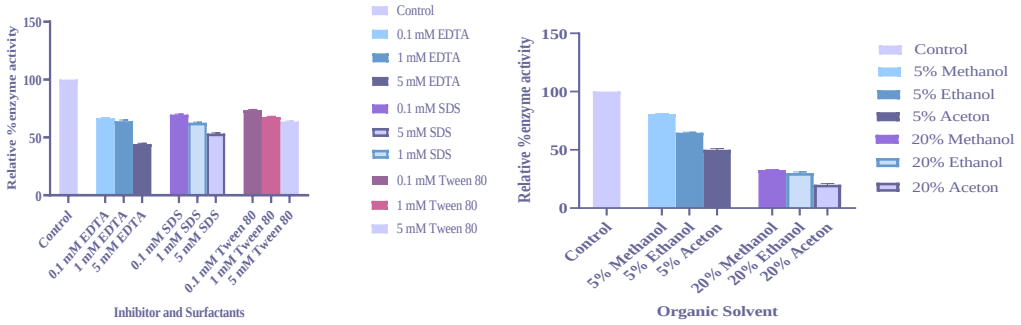


Figure S2: Effect of various inhibitor, surfactants, and organic solvents

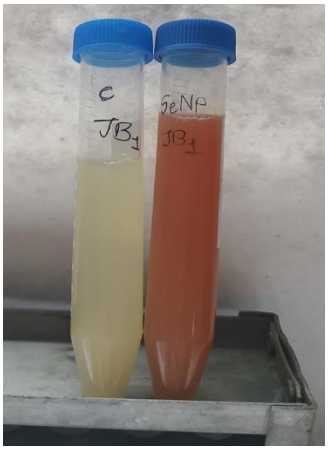


Figure S3 Lac@SeNp formation

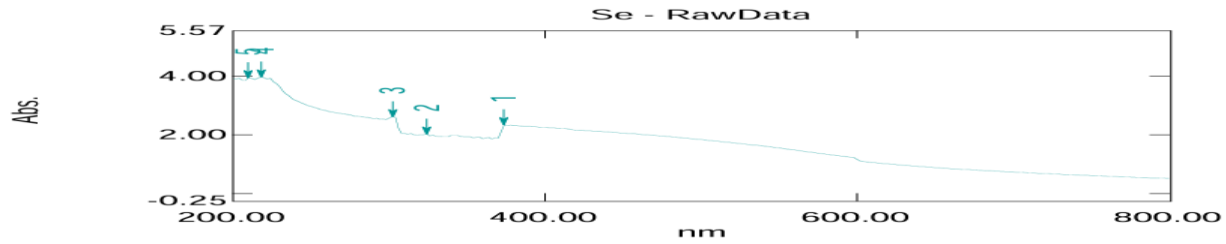


Figure S4 UV spectra of lac@SeNp

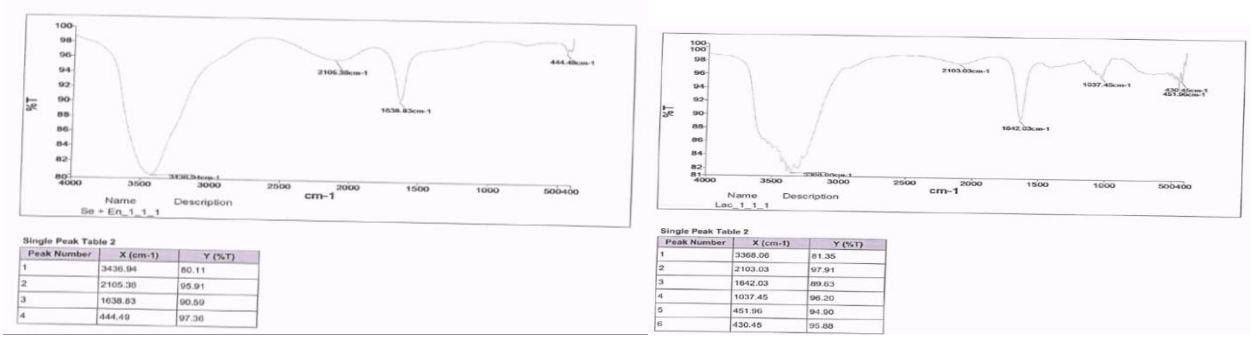


Figure S5 FTIR spectra of lac@SeNp and laccase enzyme

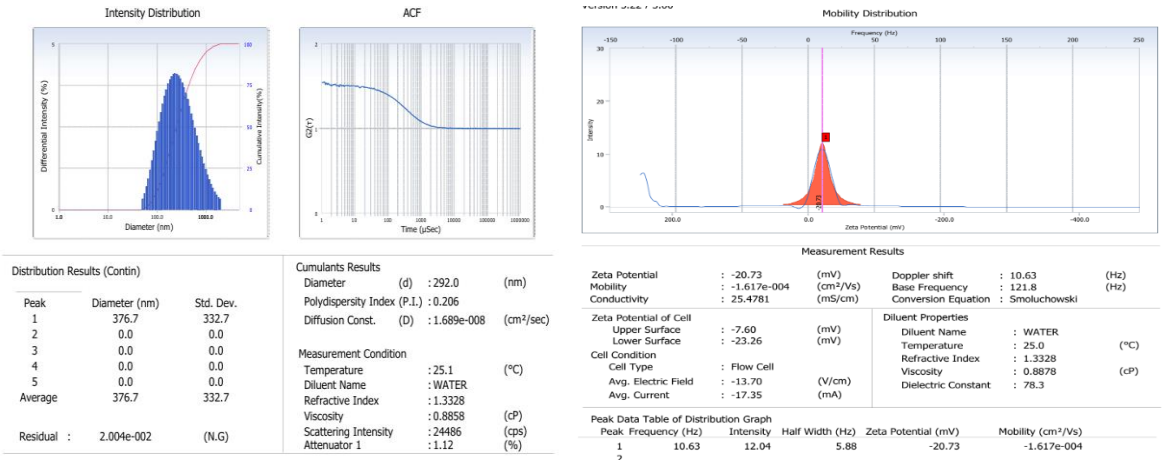
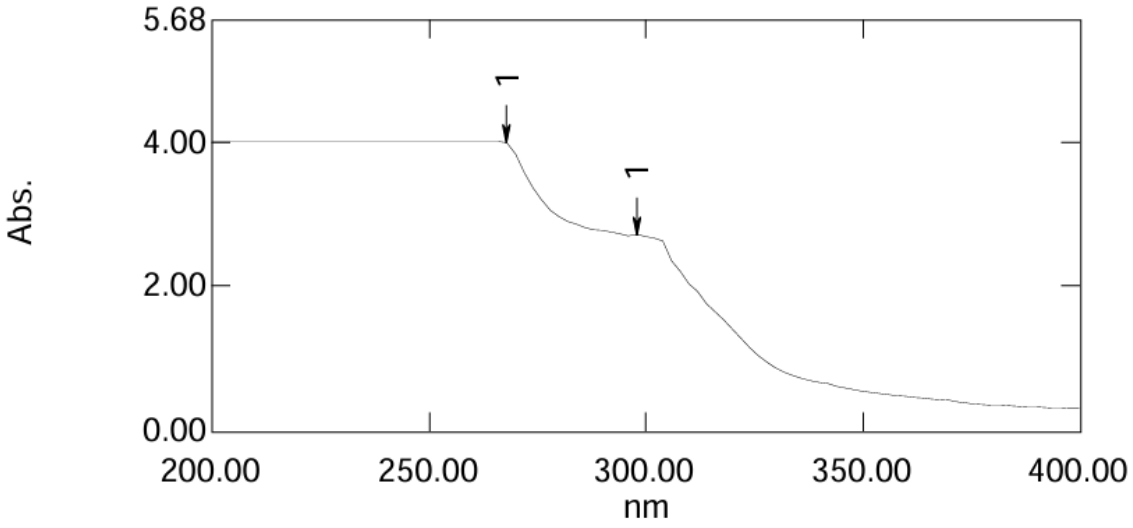


Figure S6: DLS and Zeta potential of Lac@SeNp



No.	Wavelength nm.	Absorbance	Description
1	268.0	3.983	

Figure S7 UV spectra of cypermethrin.

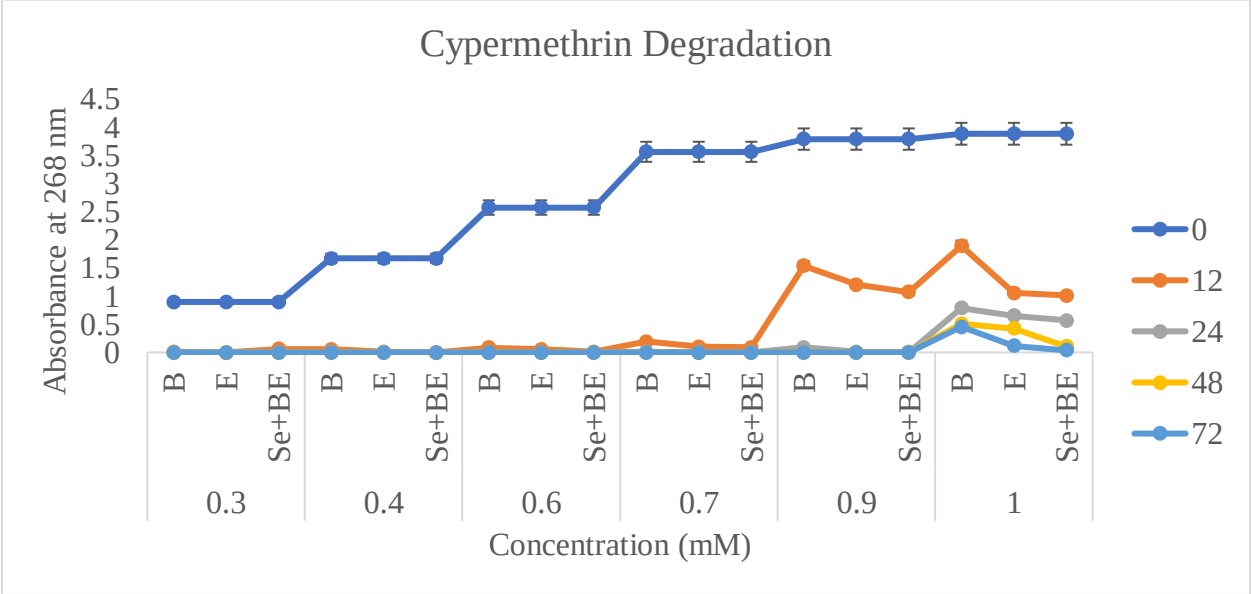
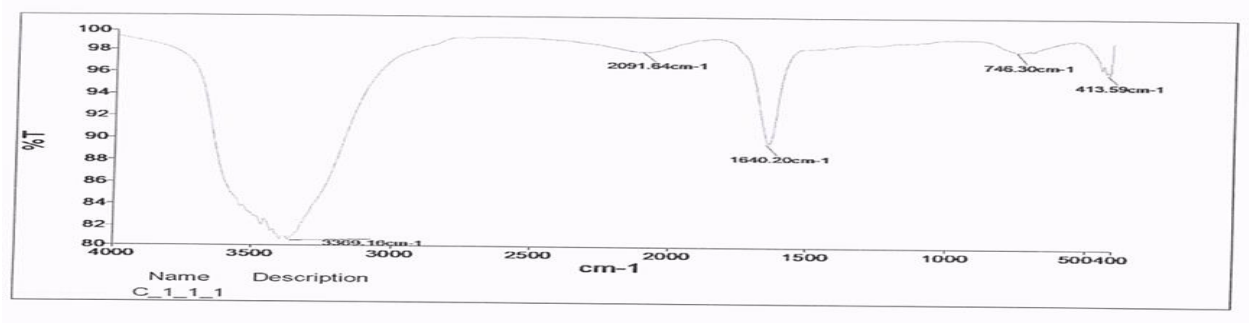
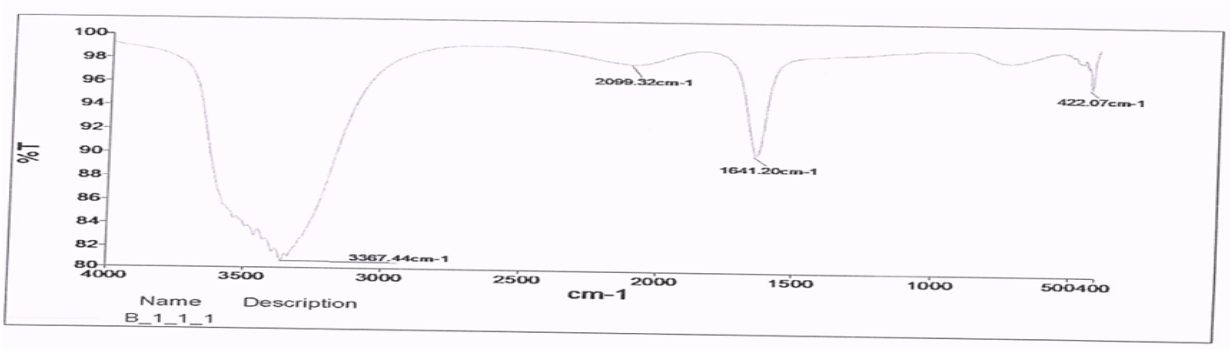
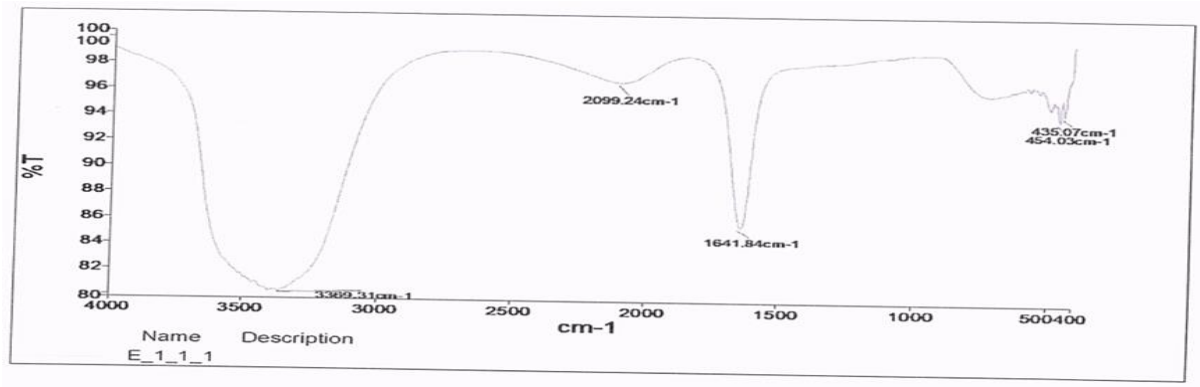


Figure S8 Cypermethrin degradation by different systems







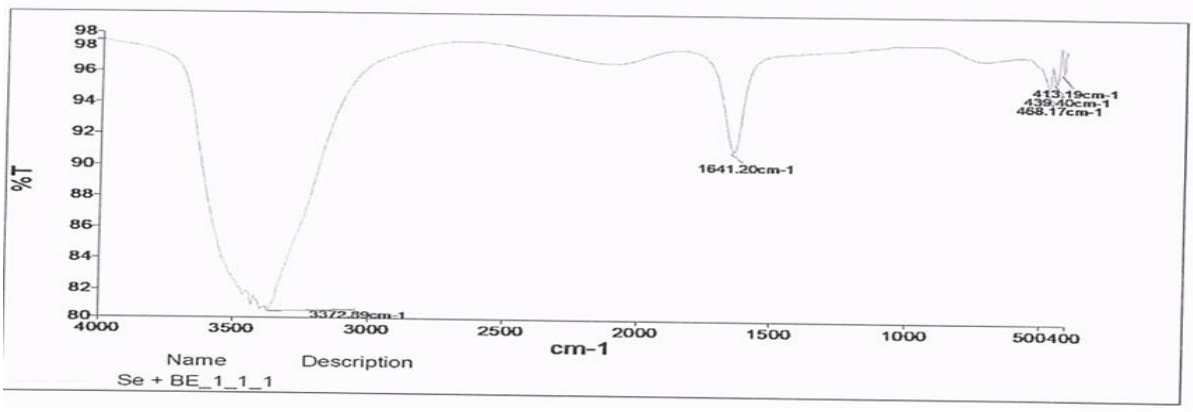


Figure S9 FTIR spectra for Control, B, E, Se+E

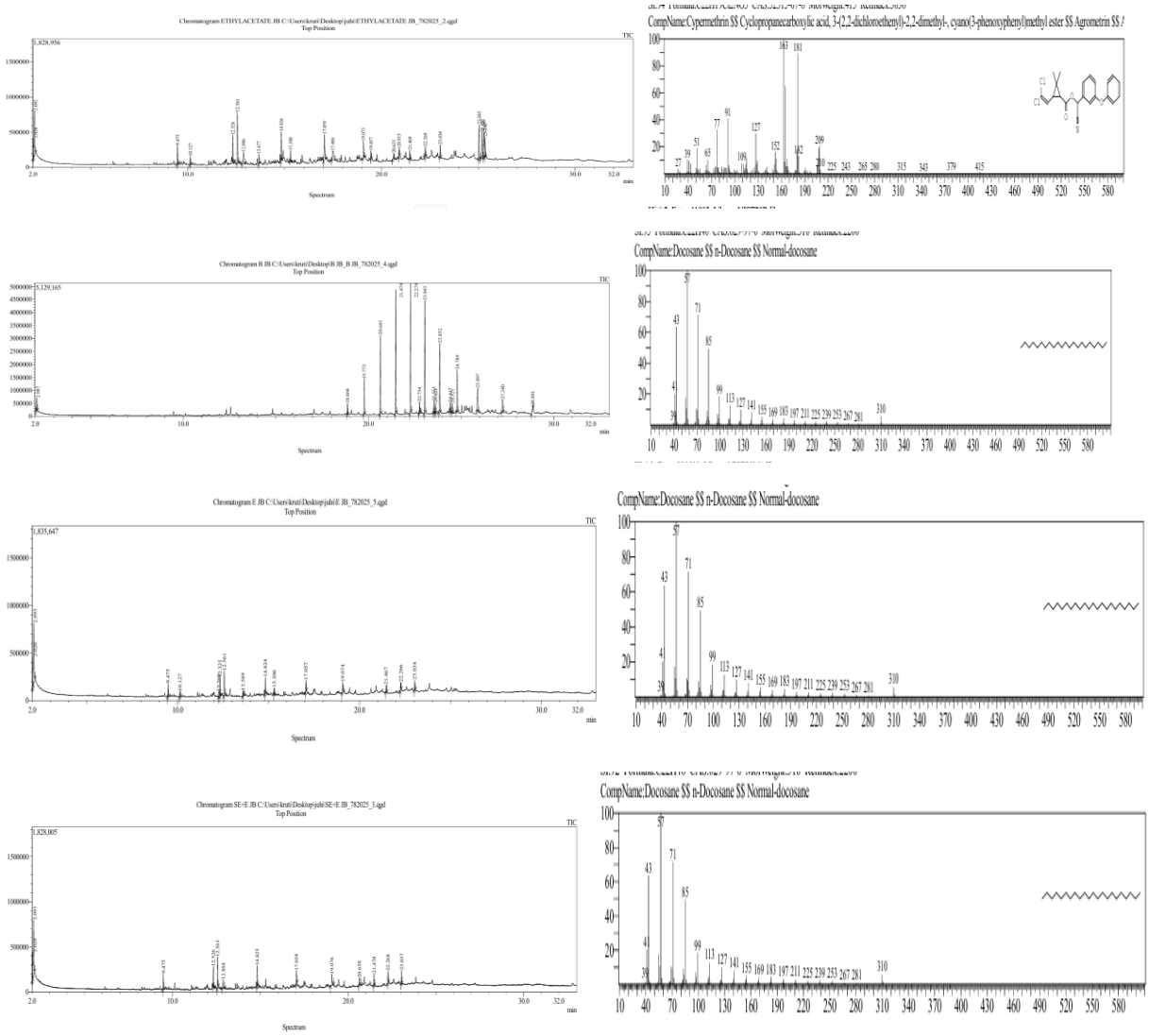


Figure S10 GC chromatogram for Control, B, E, Se+E