Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Enzyme-Catalysed Biodegradation of Carbon Dots follow Sequential Oxidation in a Time Dependent Manner

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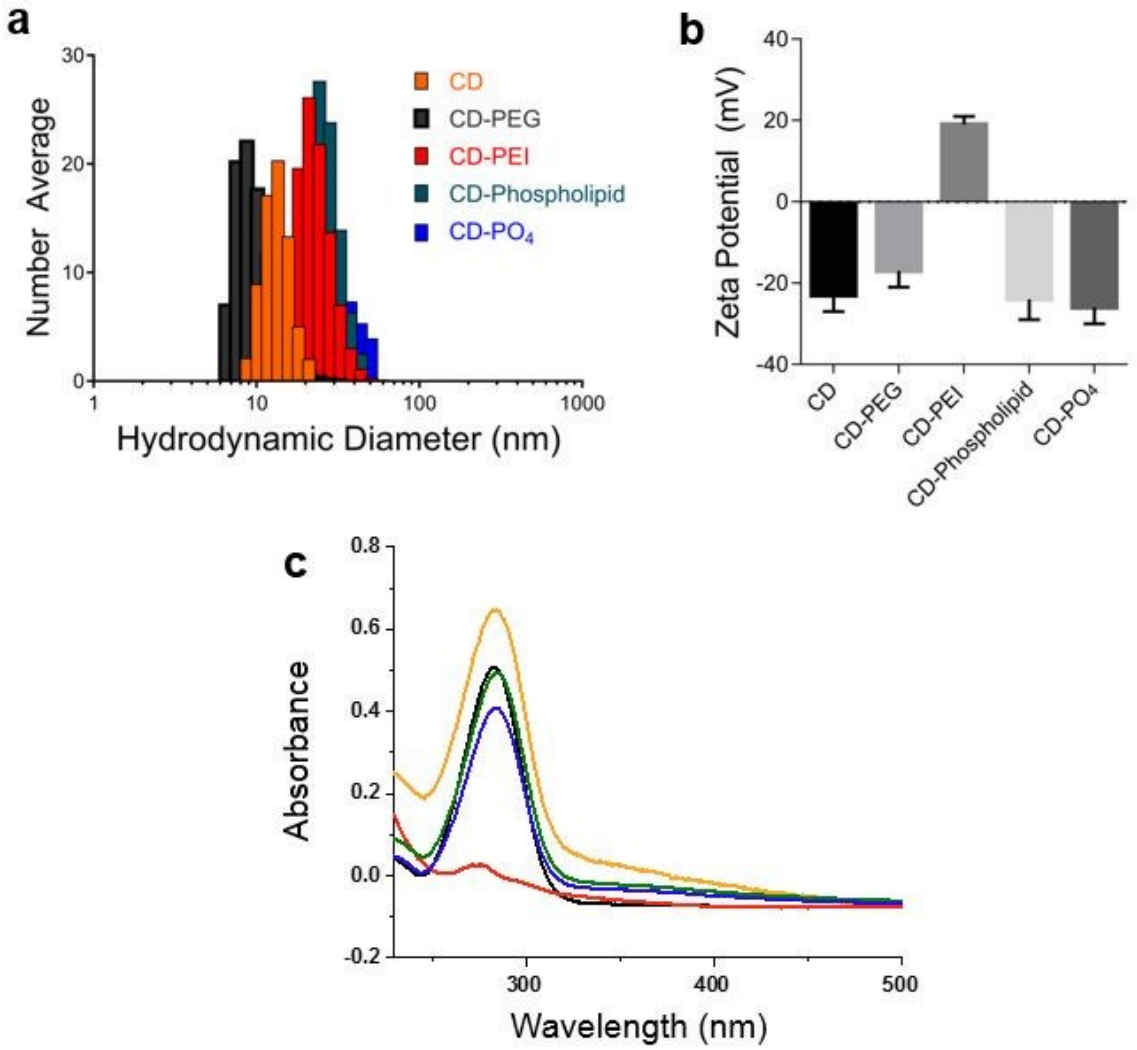


Figure S1. Physiochemical characterization of different CDs performed by (a) dynamic light scattering (DLS) to get their hydrodynamic diameters, (b) zeta potential measurements and (c) UV-Vis absorption spectra.

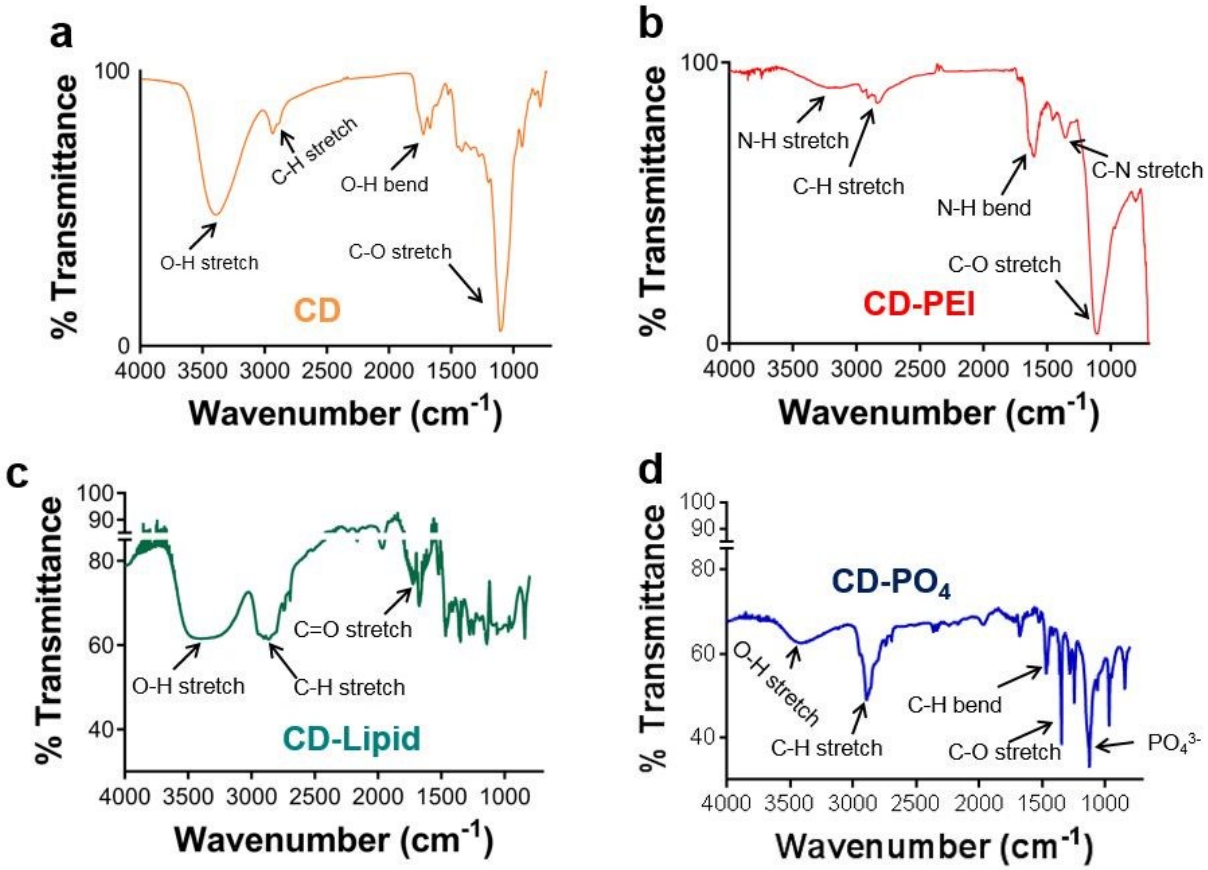


Figure S2. Preliminary Fourier-transform infrared spectroscopy (FT-IR) measurements performed on (a) CD, (b) CD-PEI, (c) CD-Lipid and (d) CD-PO_4 to gather insights into their chemical features.

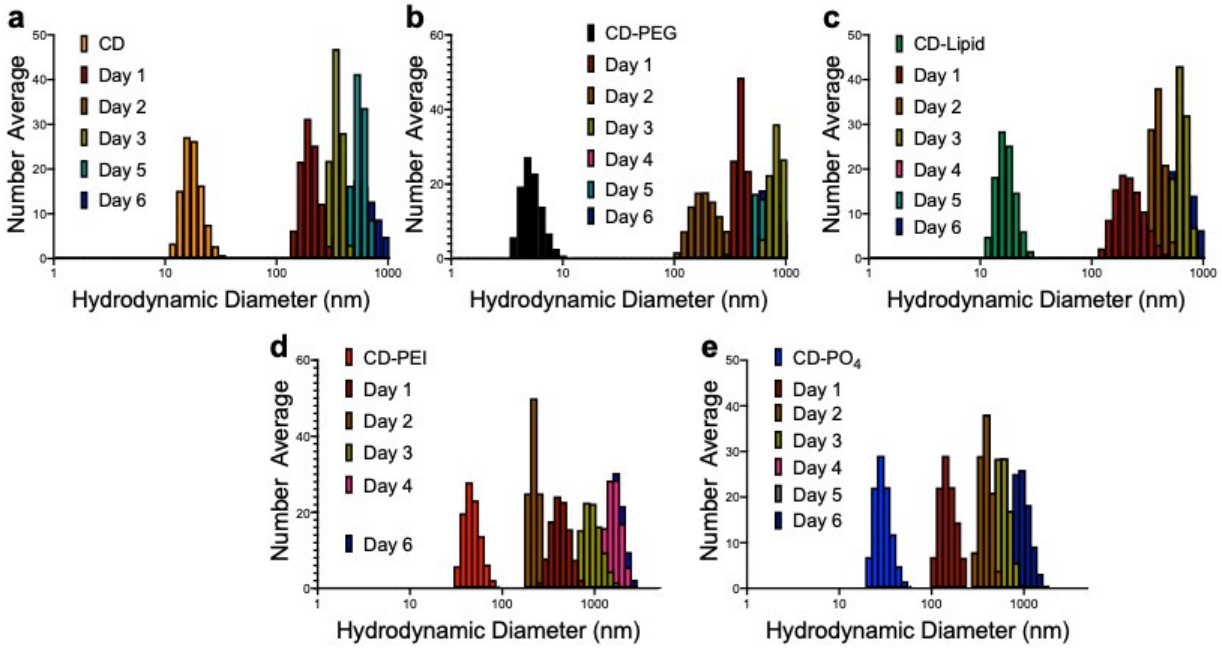


Figure S3. DLS measurements were collected for (a) CD, (b) CD-PEG, (c) CD-Lipid, (d) CD-PEI, and (e) CD-PO_4 during the 1 week in which it was subjected to lipase-mediated degradation.

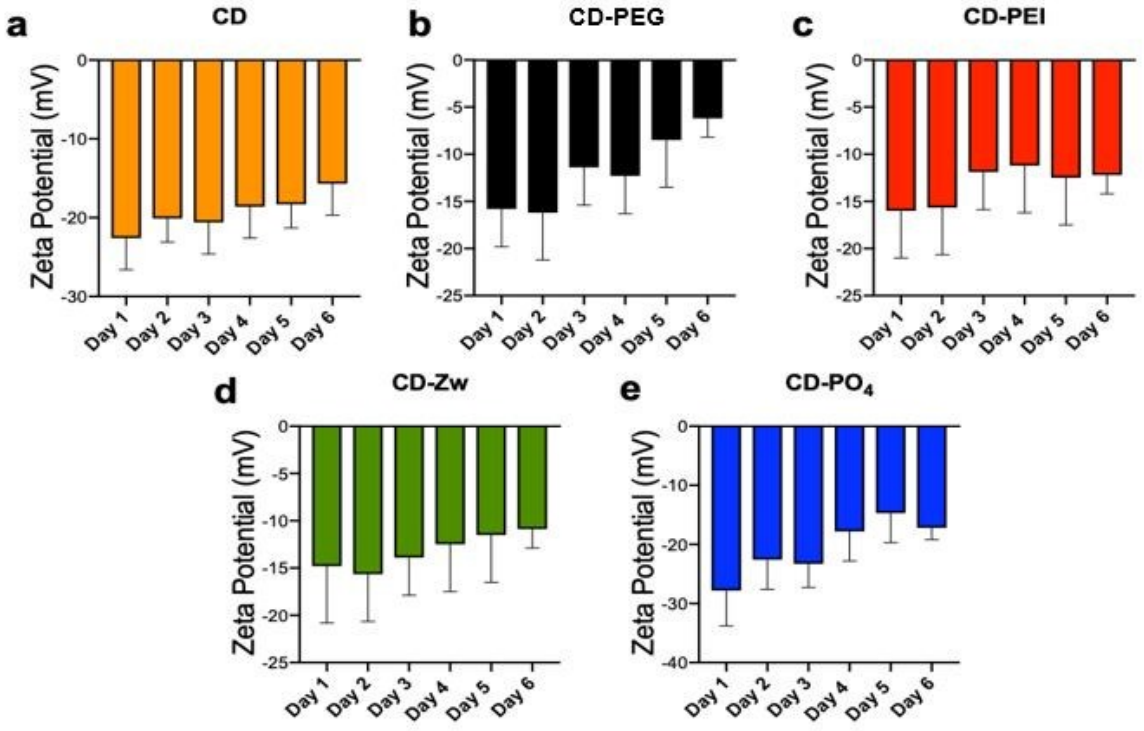


Figure S4. Zeta potential measurements were collected for (a) CD, (b) CD-PEG, (c) CD-Lipid, (d) CD-PEI, and (e) CD-PO_4 during the 1 week in which it was subjected to lipase-mediated degradation.

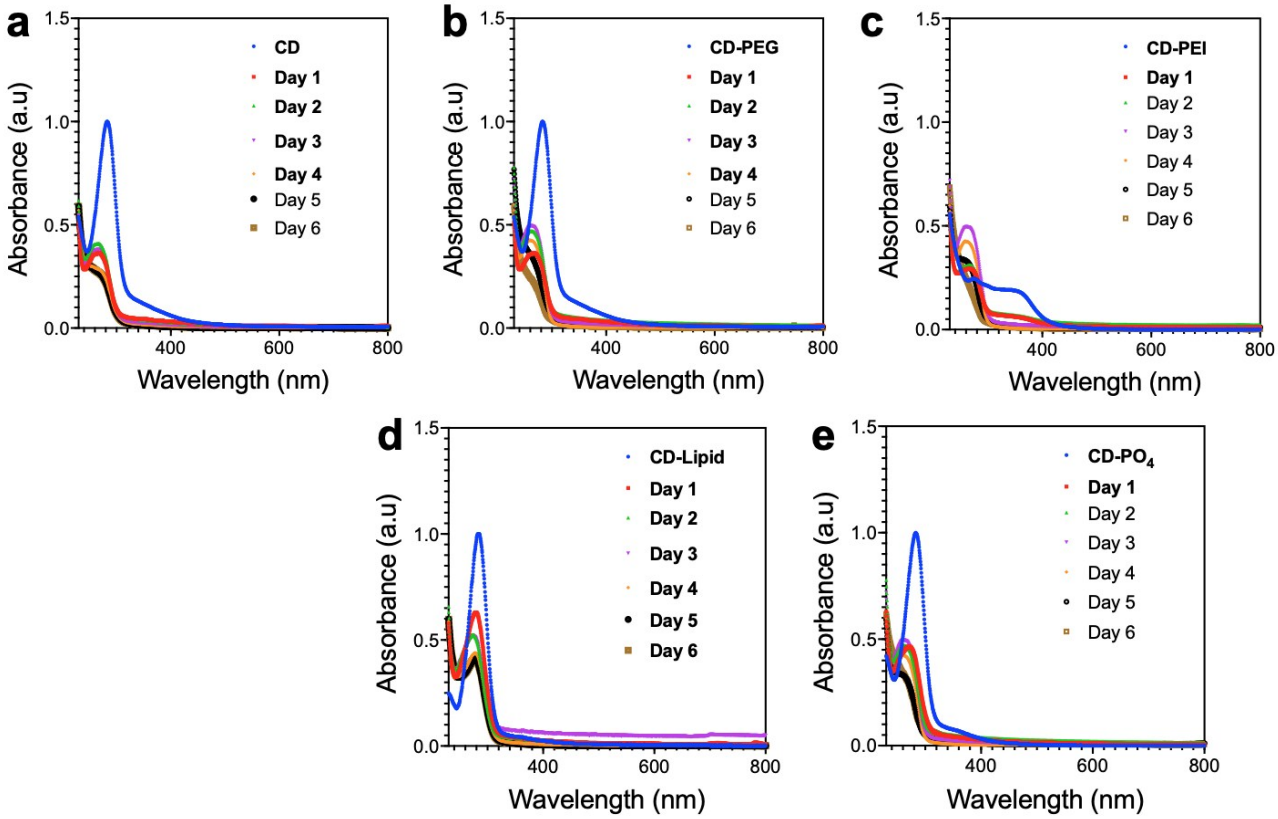


Figure S5. UV-Vis absorption spectra were collected for (a) CD, (b) CD-PEG, (c) CD-Lipid, (d) CD-PEI, and (e) CD-PO_4 during the 1 week in which it was subjected to lipase-mediated degradation.

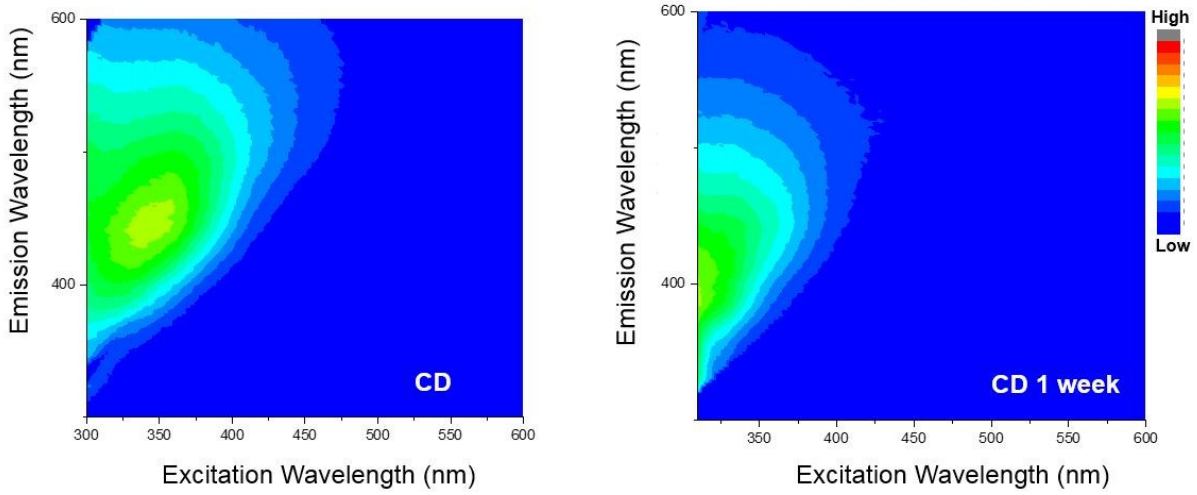


Figure S6. Normalized Excitation-Emission 2D contour for (a) CD and (b) CD degraded in presence of lipase for 1 week.

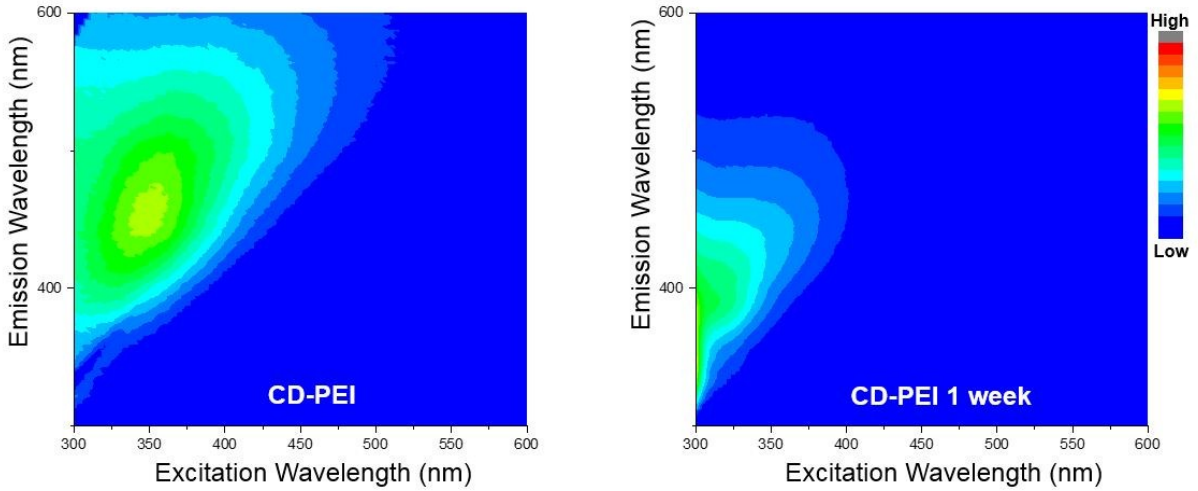


Figure S7. Normalized Excitation-Emission 2D contour for (a) CD-PEI and (b) CD-PEI degraded in presence of lipase for 1 week.

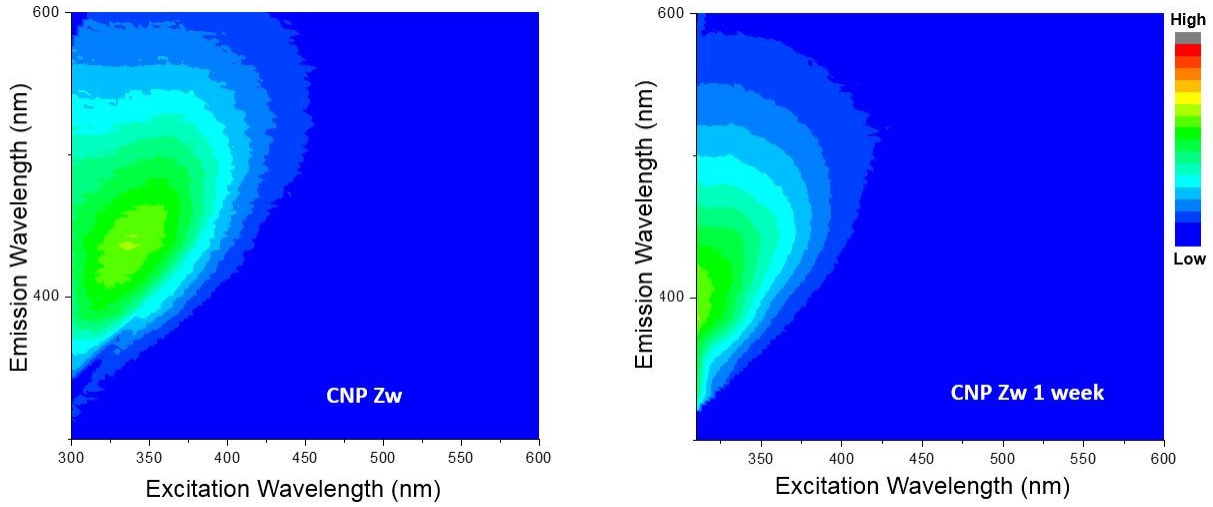


Figure S8. Normalized Excitation-Emission 2D contour for (a) CD-Lipid and (b) CD-Lipid degraded in presence of lipase for 1 week

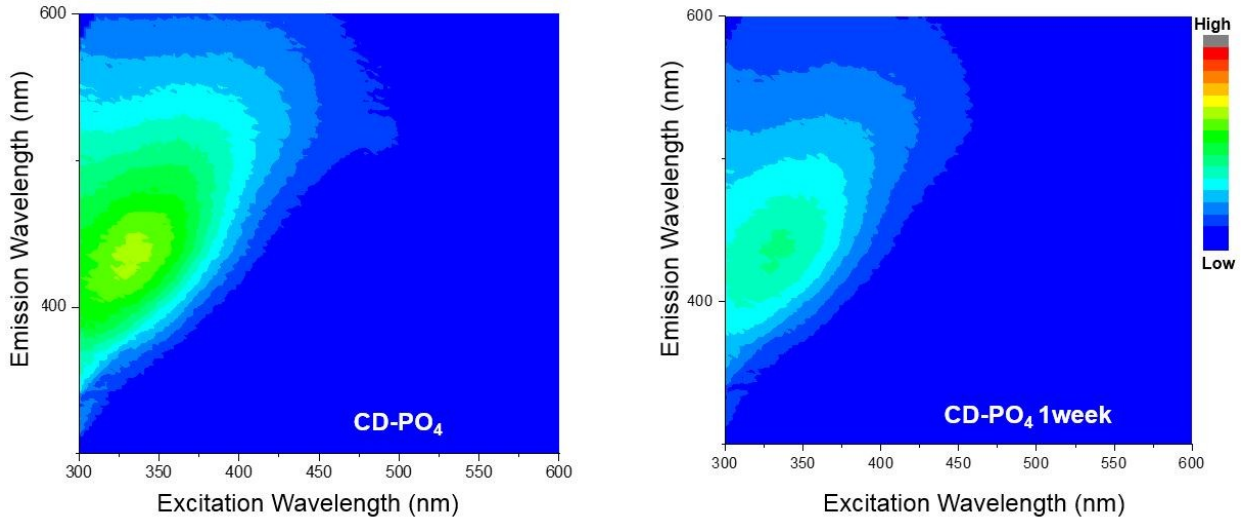


Figure S9. Normalized Excitation-Emission 2D contour for (a) CD-PO_4 and (b) CD-PO_4 degraded in presence of lipase for 1 week

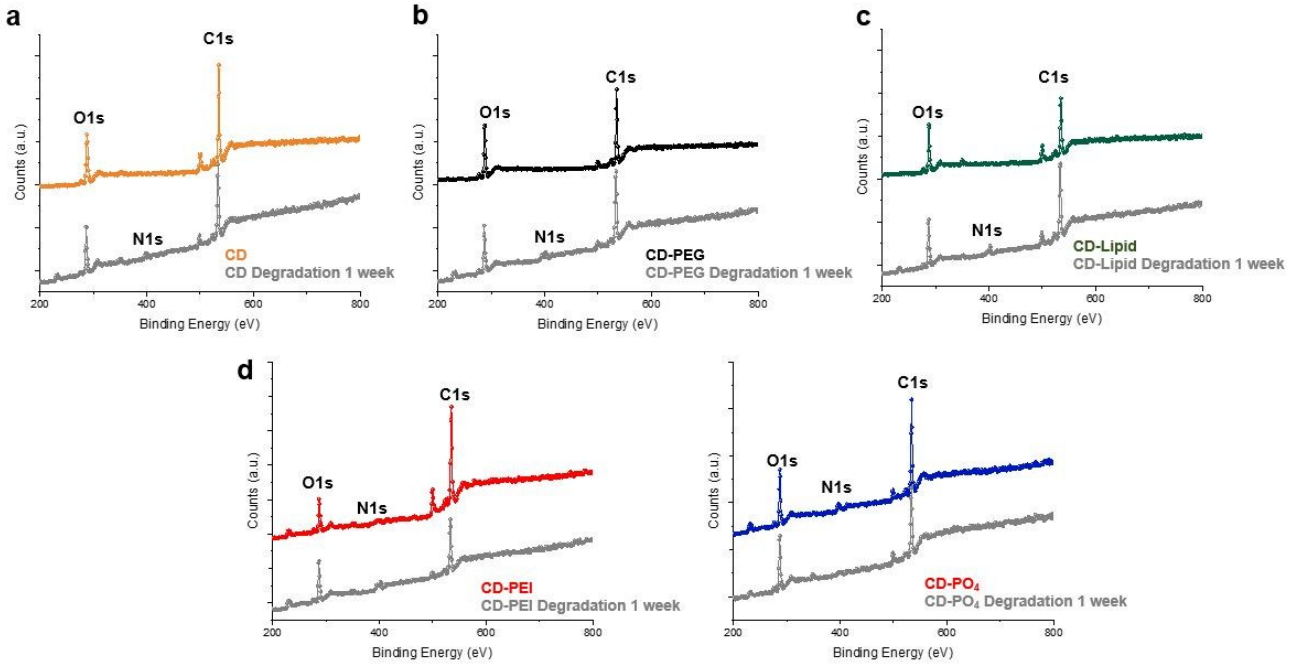


Figure S10. X-ray photoelectron spectroscopy (XPS) measurements of all CDs before, and after lipase-mediated degradation for 1 week.

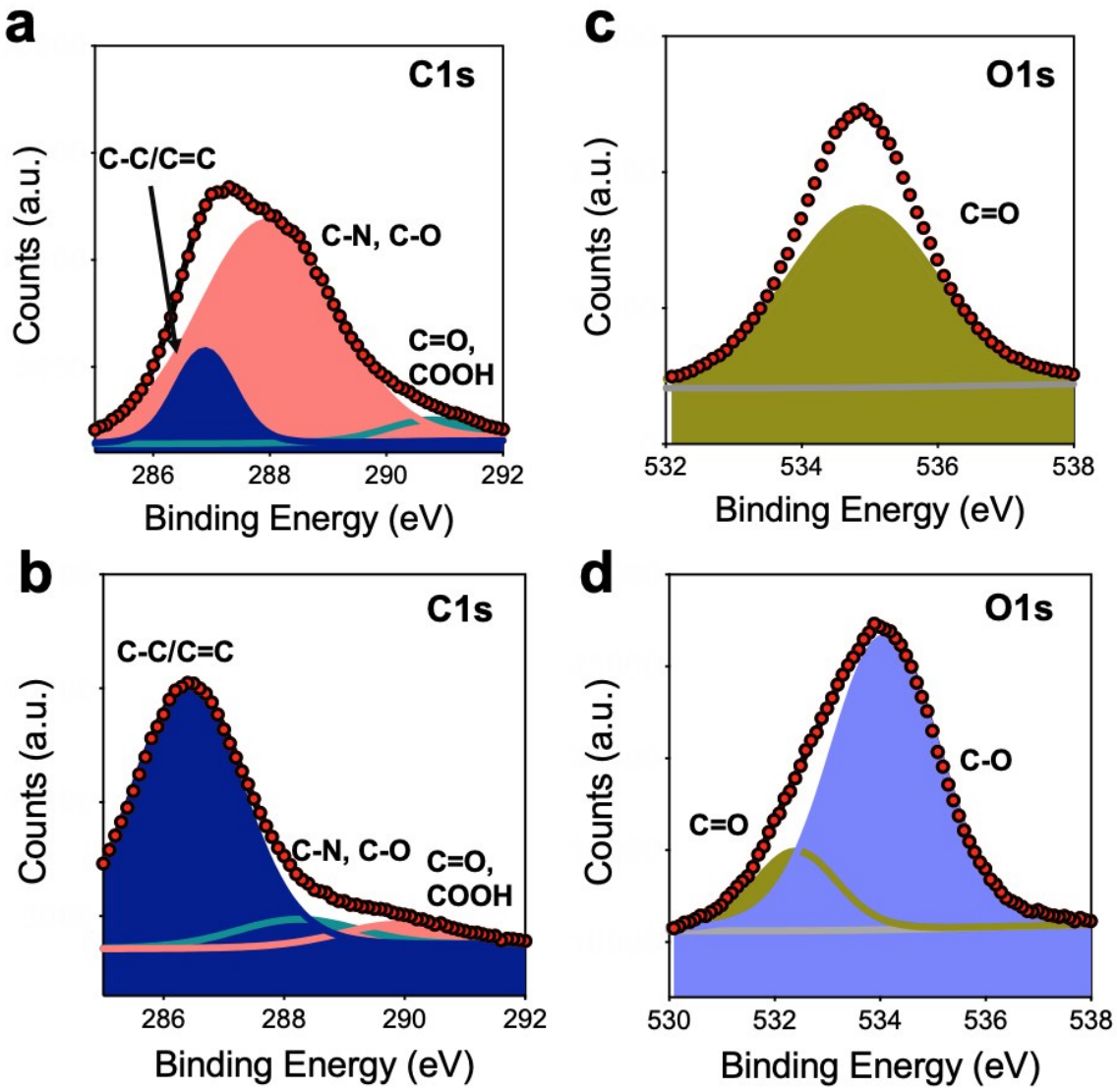


Figure S11. XPS narrow scan regions for (a, b) C1s and (c, d) O1s (with specific positions of signal from different bonds present, before and after lipase-mediated degradation of CD.

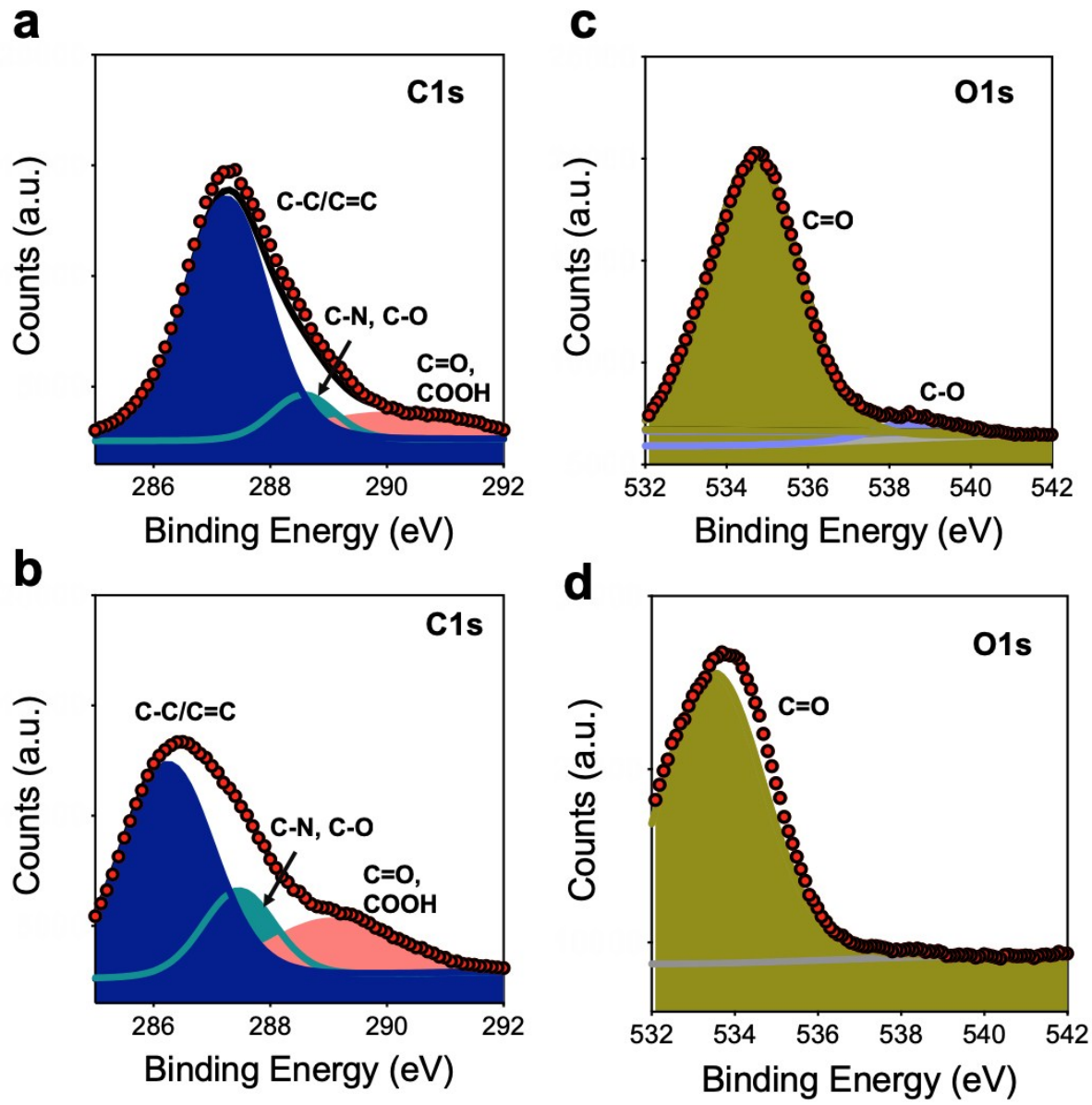


Figure S12. XPS narrow scan regions for (a, b) C1s and c, d) O1s (a, c) C1s and (b, d) O1s with specific positions of signal from different bonds present, before and after lipase-mediated degradation of CD-Lipid.

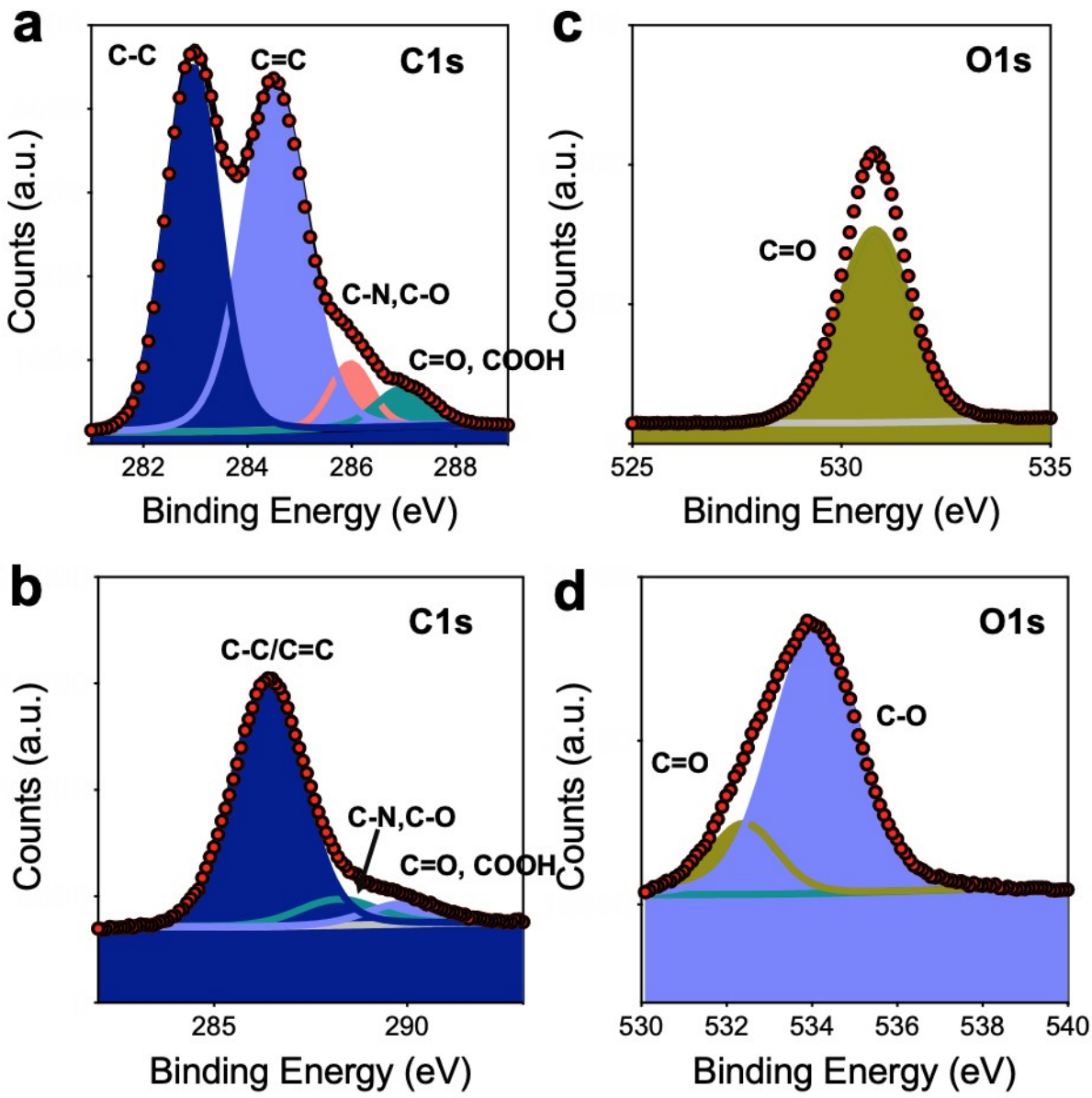


Figure S13. XPS narrow scan regions for (a, b) C1s and (c,d) O1s with specific positions of signal from different bonds present, before and after lipase-mediated degradation of CD-PEG.

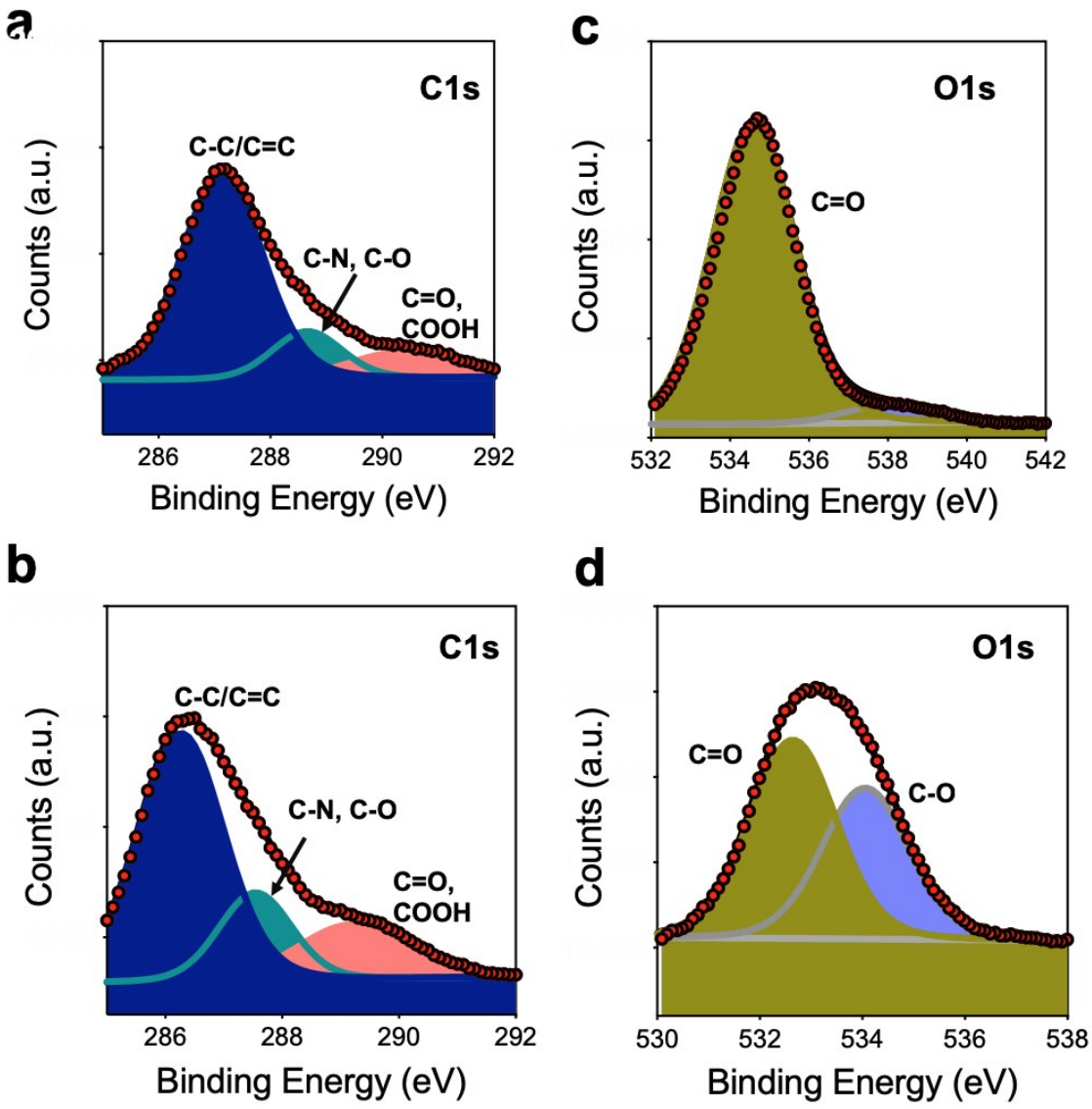


Figure S14. XPS narrow scan regions for (a, b) C1s and (c, d) O1s with specific positions of signal from different bonds present, before and after lipase-mediated degradation of CD-PEI.

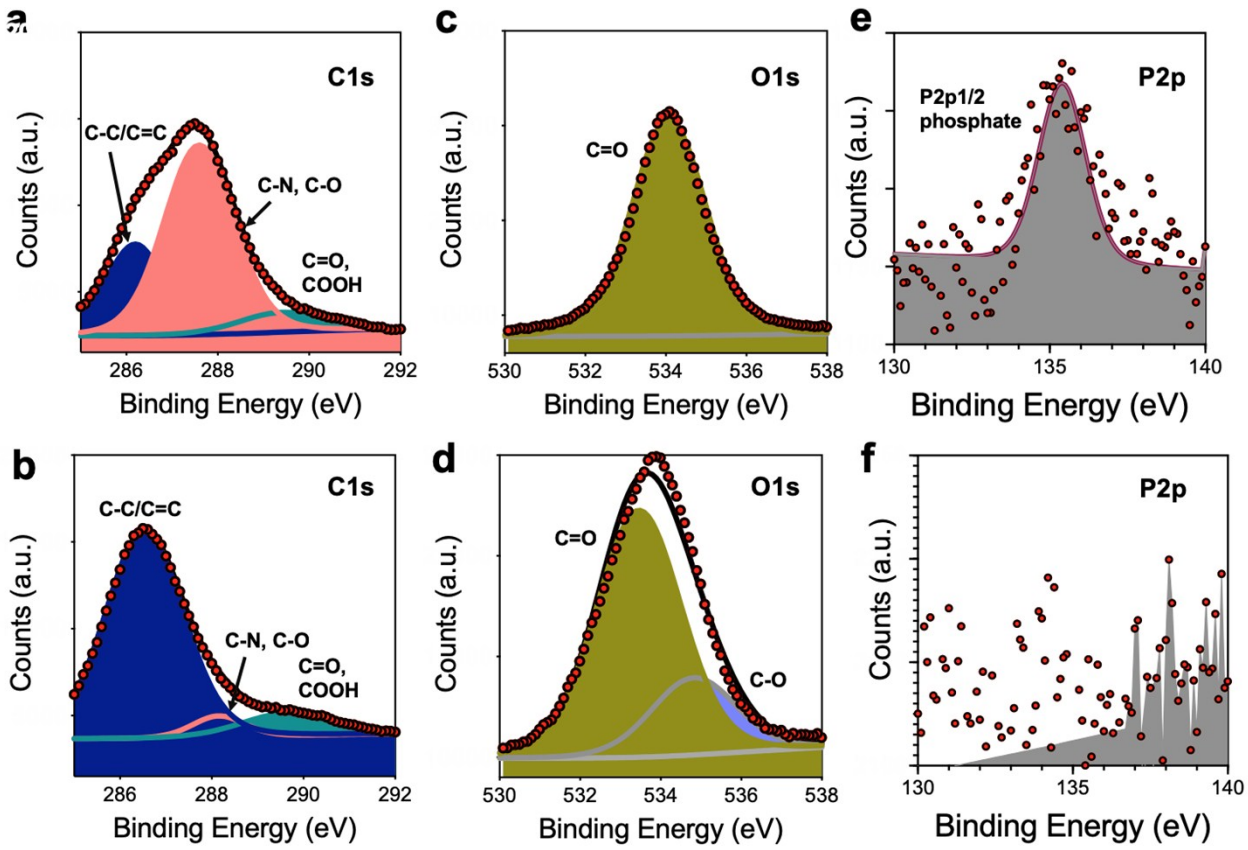


Figure S15. XPS narrow scan regions for (a, b) C1s,(c, d) O1s and (e, f) P2p with specific positions of signal from different bonds present, before and after lipase-mediated degradation of CD-PO_4.

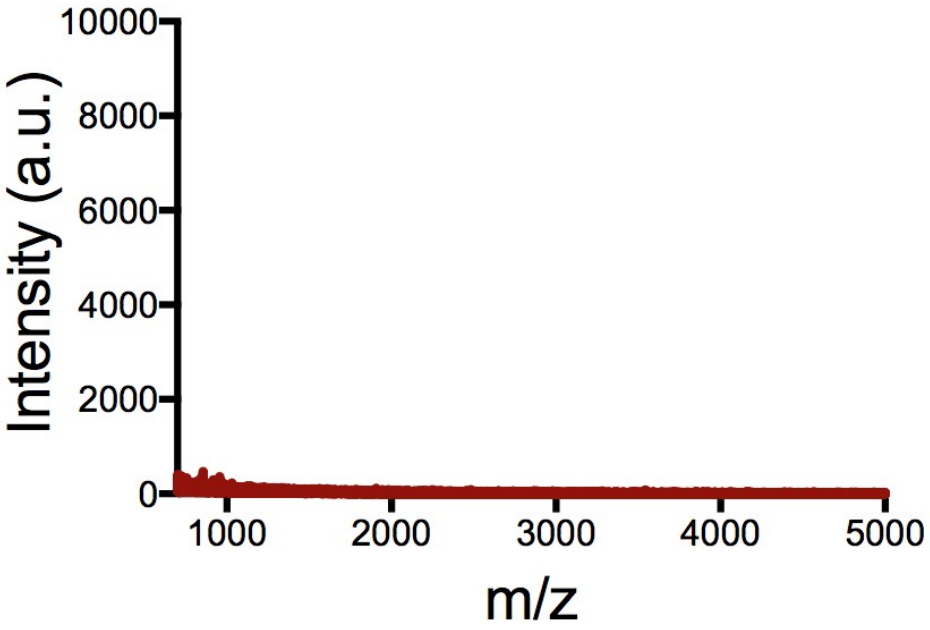


Figure S16. MALDI-TOF spectra of lipase enzyme in DI water.

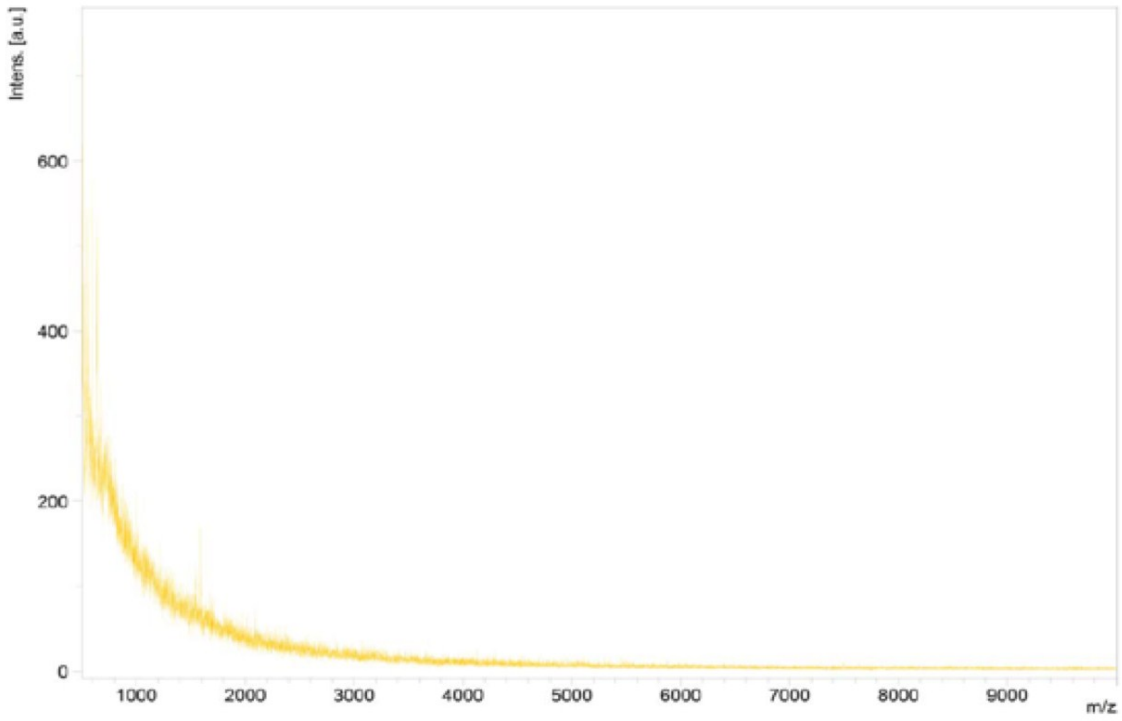
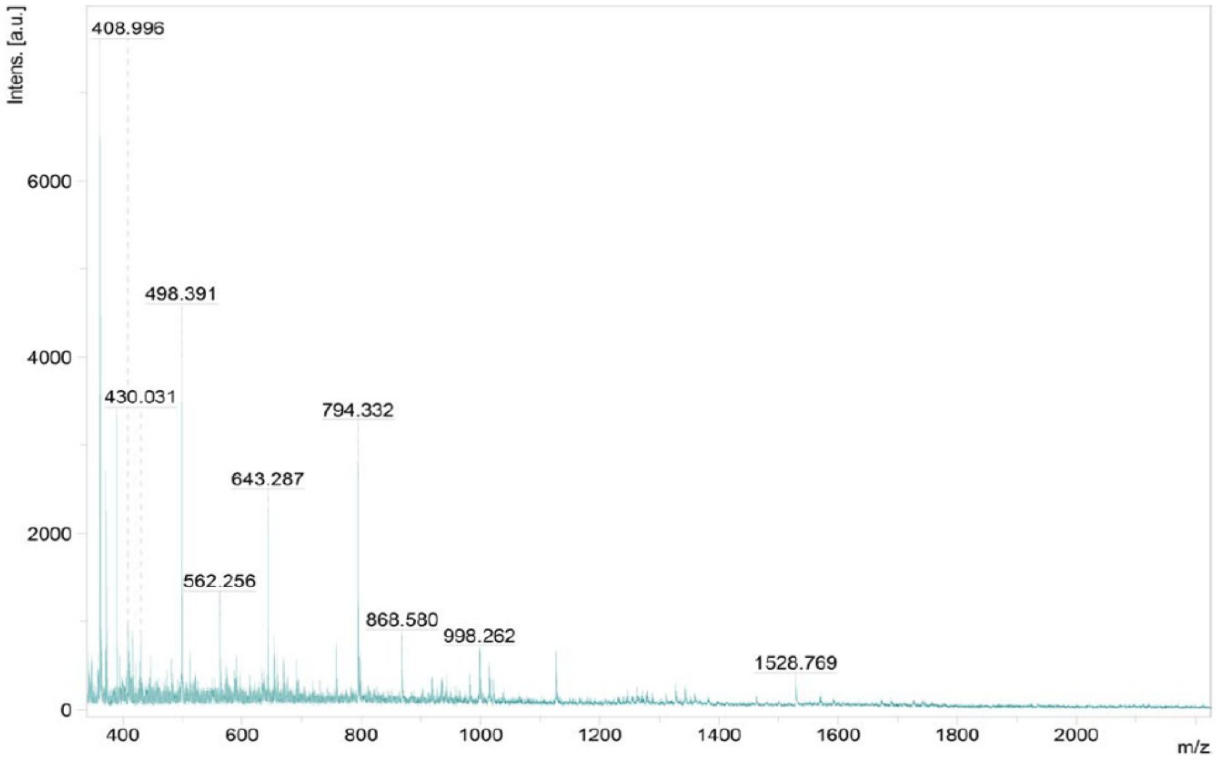


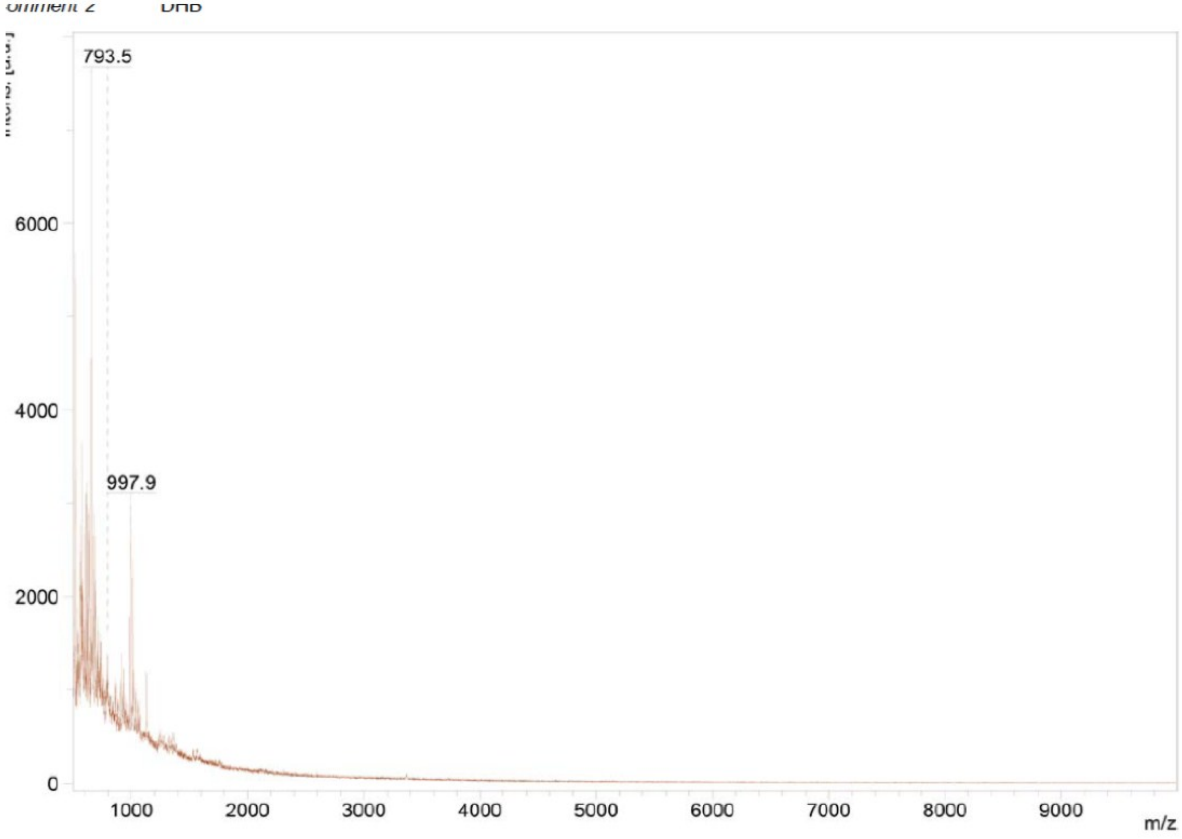
Figure S17. MALDI-TOF spectra of CD-Bare.



Explanation of peaks based on oxidation scheme:

(308 x 2) + 176 + $2H^+$ = 794
340 + 308 + 176 + 126 + 46 + $2H^+$ = 998
340 + 308 + 176 + (3 x 126) + (2 x 116) + (2 x 46) + $2H^+$ = 1528

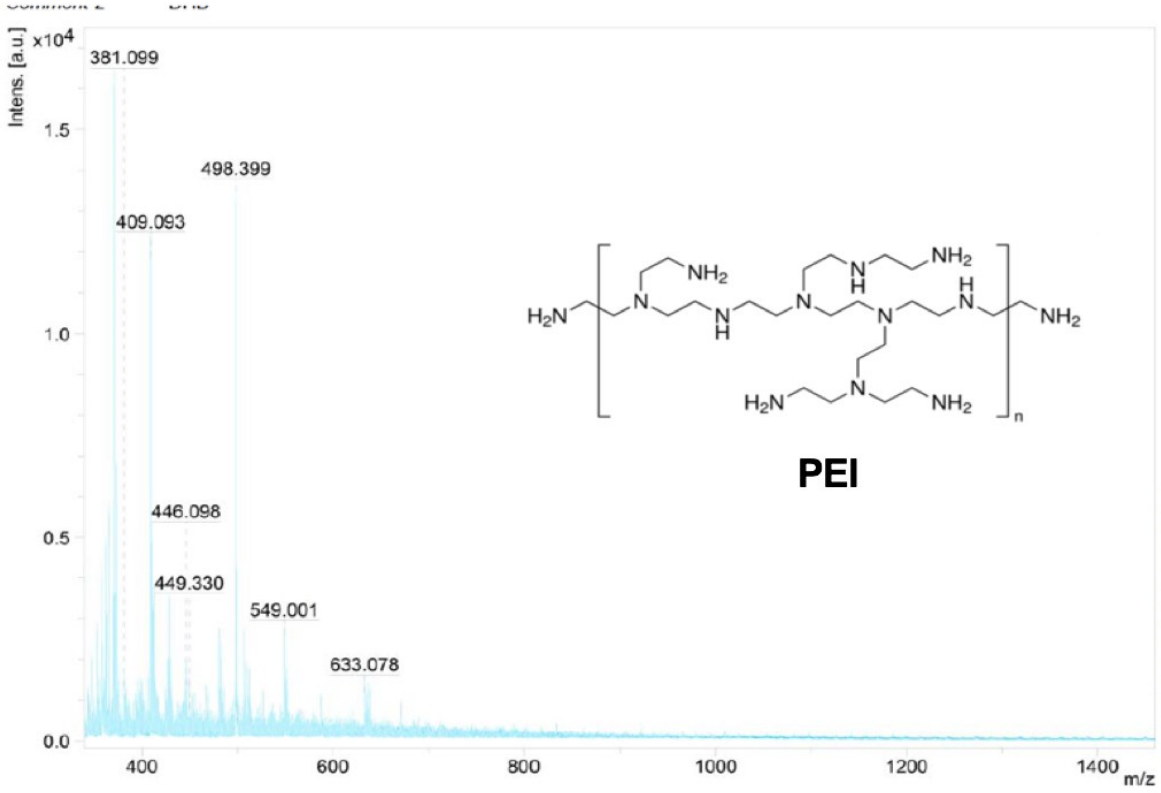
Figure S18. MALDI-TOF spectra of CD degraded for 24h with corresponding oxidation scheme for degraded fragments.



Explanation of peaks based on oxidation scheme:

(308 x 2) + 176 + $1H^+$ = 793
308 + (2 x 170) + 176 +126 + 46 + $1H^+$ = 997

Figure S19. MALDI-TOF spectra of CD degraded for 1 week with corresponding oxidation scheme for degraded fragments.

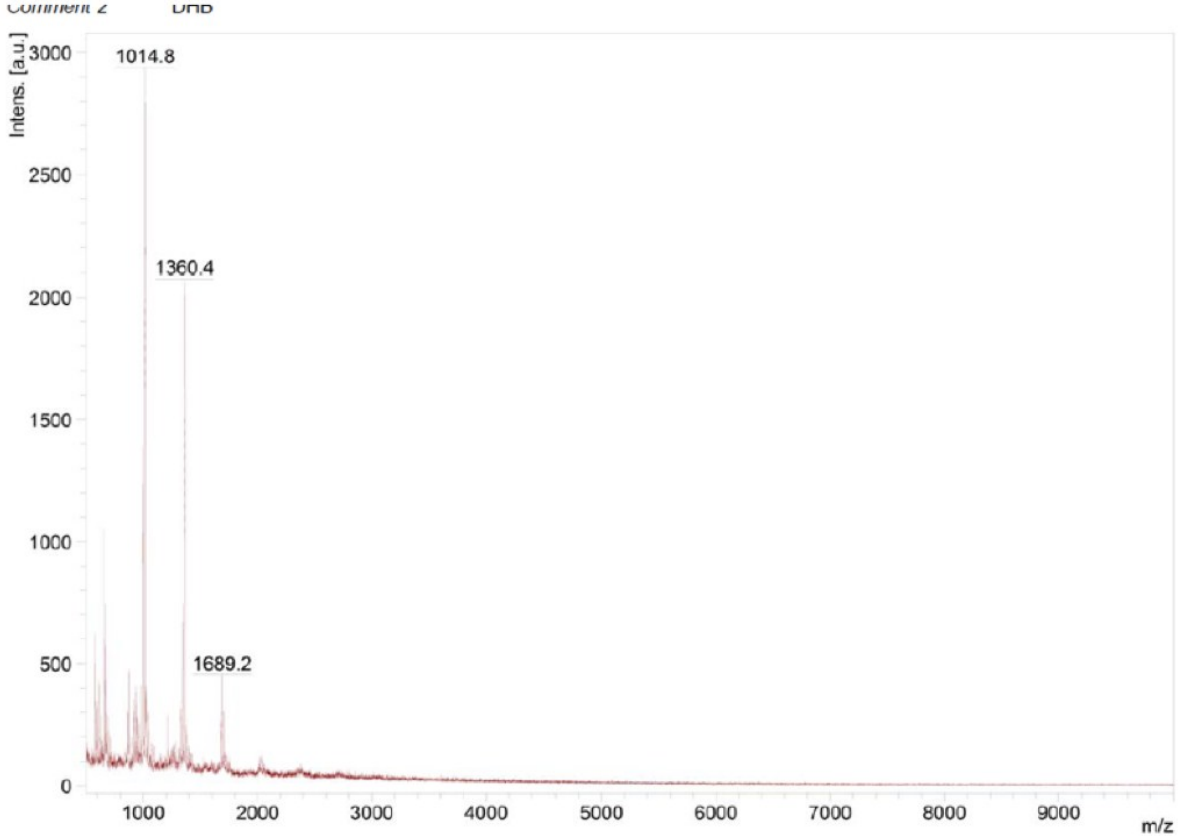


Explanation of peaks:

176 + 232 + $1H^+$ = 409
170 + 275 + $1H^+$ = 446
162 + 275 + $2H^+$= 449
178 + 318 + $2H^+$ = 498

232, 275 and 318 are fractions of PEI

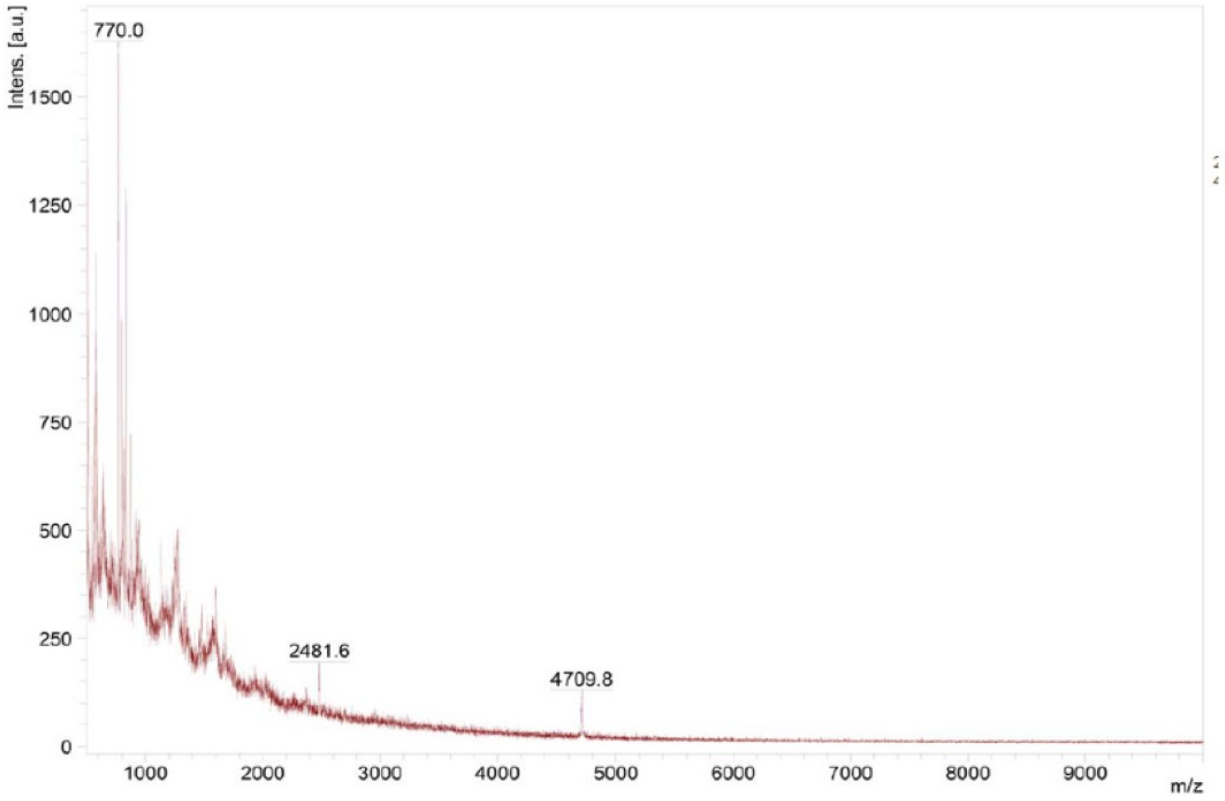
Figure S20. MALDI-TOF spectra of CD-PEI with corresponding peaks being assigned.



Explanation of peaks based on oxidation scheme:

174 + 490 + (3 x 116) + $1H^+$ = 1014
174 + 490 + (4 x 116) + (5 x 46) + $2H^+$ = 1360
170 + 490 + (5 x 116) + (7 x 46) + 126 + $1H^+$= 1689

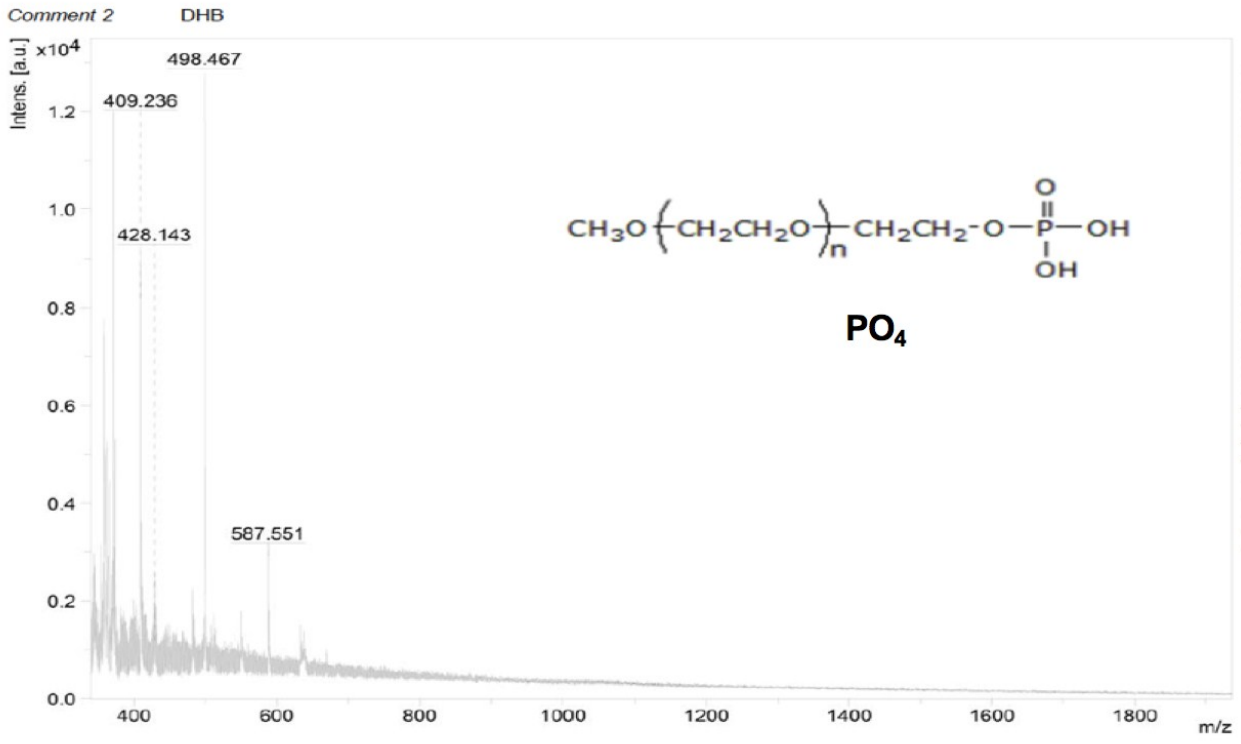
Figure S21. MALDI-TOF spectra of CD-PEI degraded for 24h with corresponding oxidation scheme for degraded fragments.



Explanation of peaks based on oxidation scheme:

162 + 490 + 116 + $2H^+$ = 770
174 + 490 + 533 + (6 x 116) + (10 x 46) + 126 + $2H^+$ = 2481

Figure S22. MALDI-TOF spectra of CD-PEI degraded for 1 week with corresponding oxidation scheme for degraded fragments.

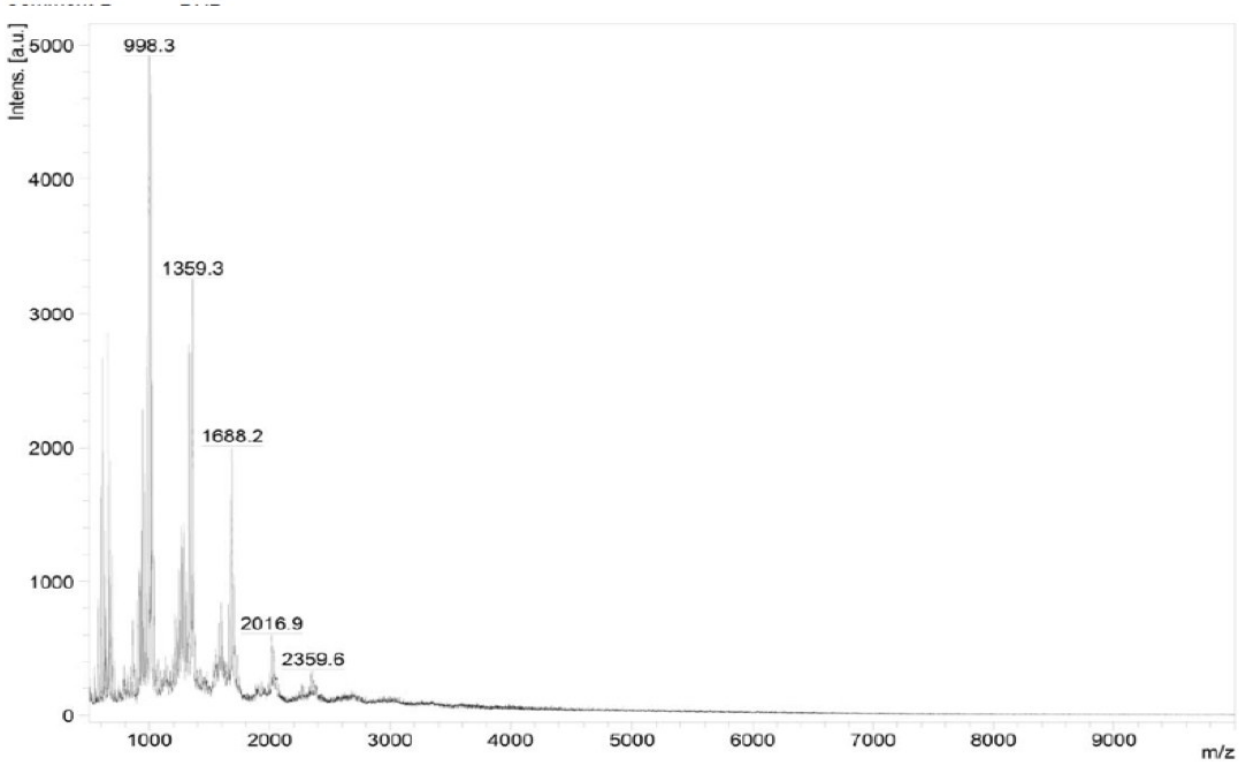


Explanation of peaks:

200 + 170 + K^+ = 409
200 + 44 + 172 + 170 + 1H^+ = 587

44 is the repeating unit

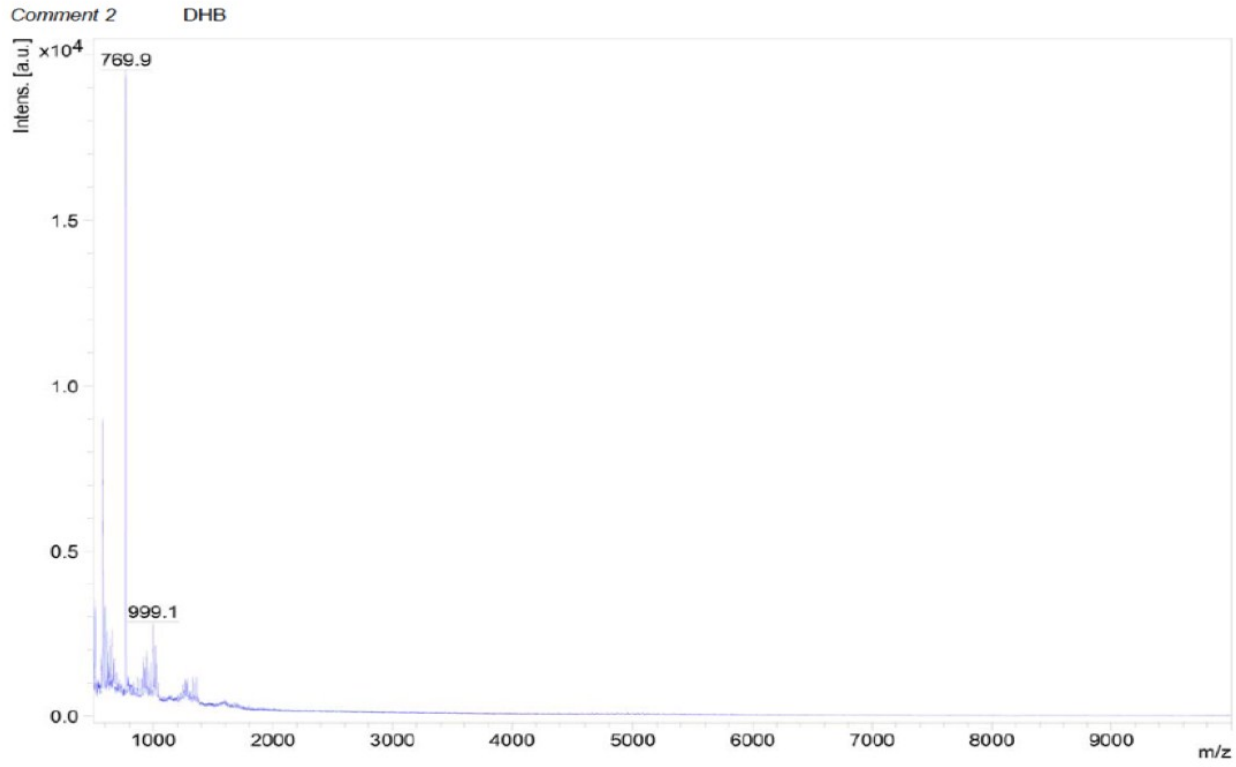
Figure S23. MALDI-TOF spectra of CD-PO_4 with corresponding peaks being assigned.



Explanation of peaks based on oxidation scheme:

176 + 200 + 44 +(2 x 126) + (2 x 116) + (2 x 46) + $2H^+$ = 998
170 + (2 x 126) + (4 x 116) + (4 x 46) + 200 + (2 x 44) + $1H^+$ = 1359
178 + (2 x 126) + (3 x 116) + (2 x 46) + 200 + (14 x 44) + $2H^+$ = 1688
178 + (2 x 126) + (5 x 116) + (6 x 46) + 200 + (12 x 44) + $2H^+$ = 2016

Figure S24. MALDI-TOF spectra of CD-PO_4 degraded for 24h with corresponding oxidation scheme for degraded fragments.



Explanation of peaks based on oxidation scheme:

180 + 116 + (4 x 46) + 200 + (2 x 44) + $1H^+$ = 769
176 + (2 x 126) + (2 x 116) + (3 x 46) + 200 + $1H^+$ = 999

Figure S25. MALDI-TOF spectra of CD-PO_4 degraded for 1 week with corresponding oxidation scheme for degraded fragments.

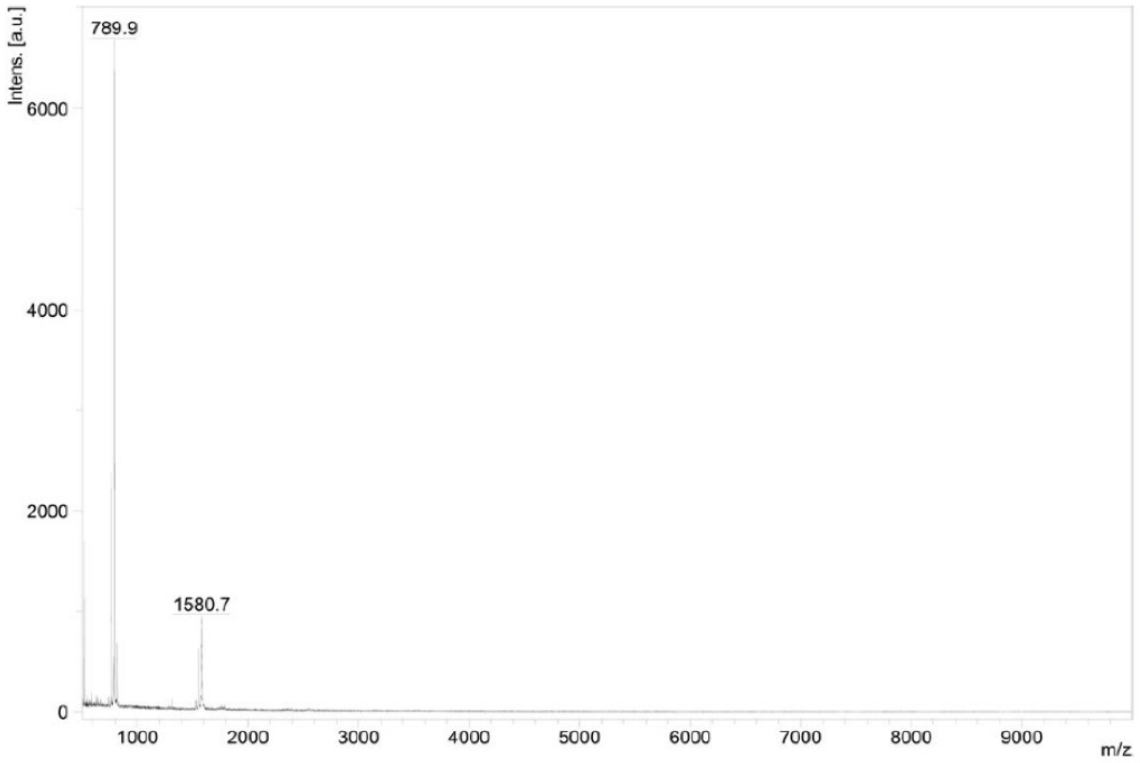
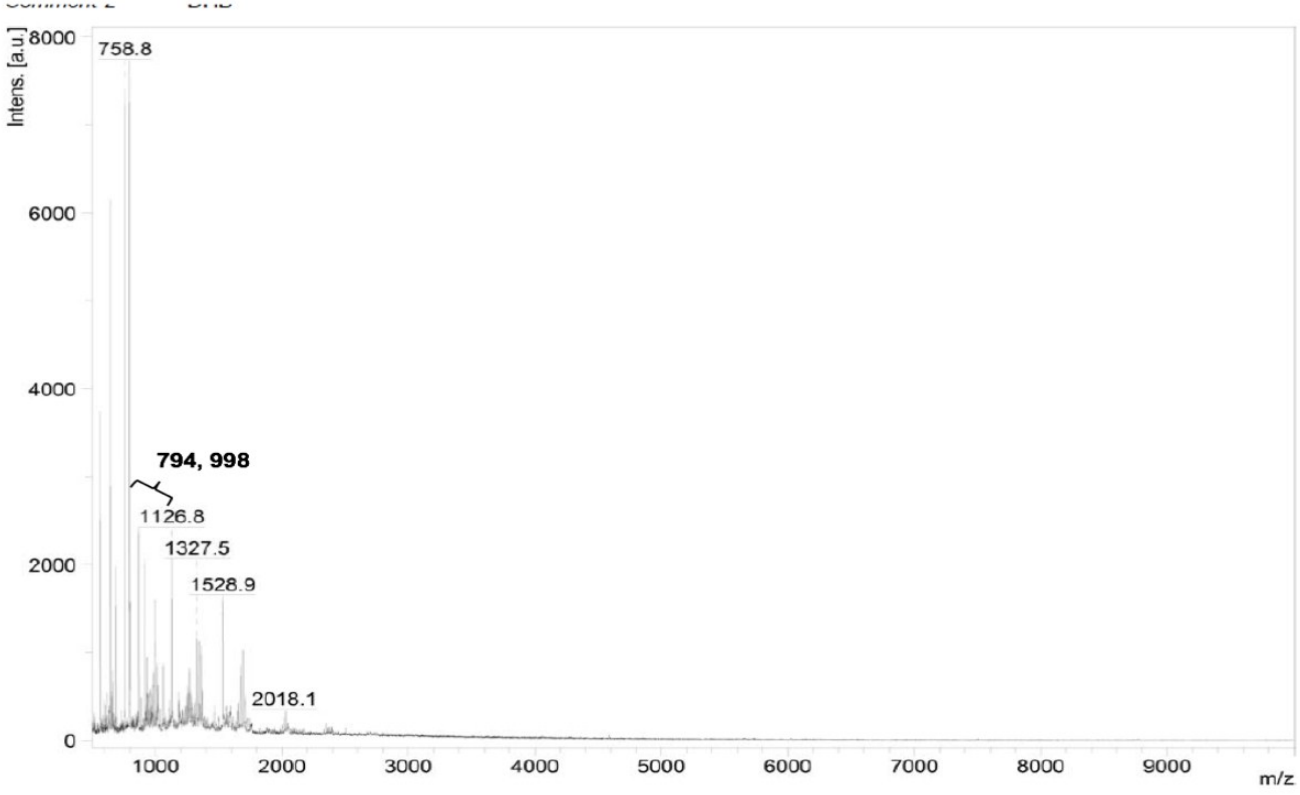


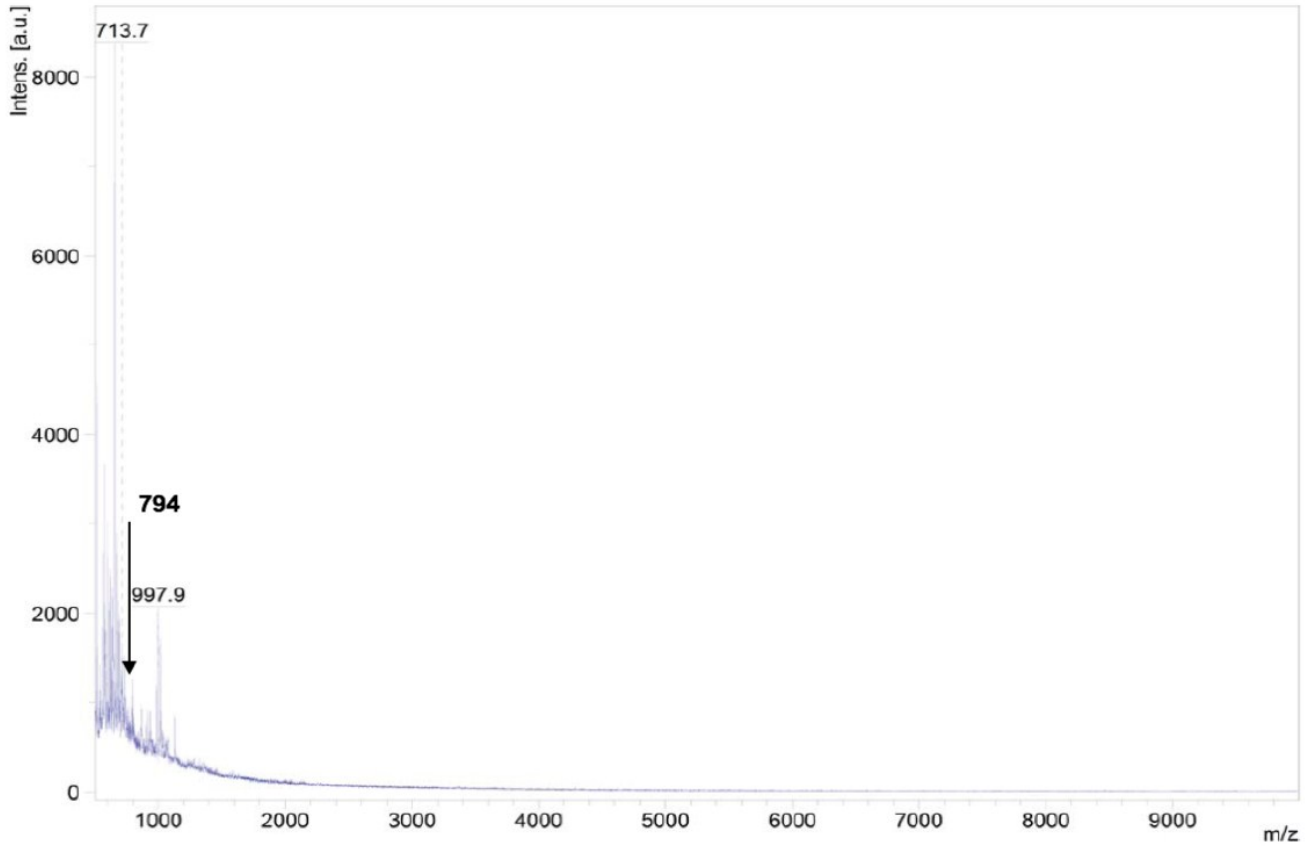
Figure S26. MALDI-TOF spectra of CD-Lipid.



Explanation of peaks based on oxidation scheme:

(308 x 2) + 176 + $2H^+$ = 794
340 + 308 + 176 + 126 + 46 + $2H^+$ = 998
340 + 308 + 176 + (3 x 126) + (2 x 116) + (2 x 46) + $2H^+$ = 1528

Figure S27. MALDI-TOF spectra of CD-Lipid degraded for 24h with corresponding oxidation scheme for degraded fragments.



Explanation of peaks based on oxidation scheme:

(308 x 2) + 176 + $2H^+$ = 794
340 + 308 + 176 + 126 + 46 + $2H^+$ = 998

Figure S28. MALDI-TOF spectra of CD-Lipid degraded for 1 week with corresponding oxidation scheme for degraded fragments.

Samples	C (%)	N (%)	O (%)	P (%)
CD	67.03	-	32.97	-
CD degraded 1 week	66.44	0.76	32.83	-
CD-PEG	74.47	-	25.53	-
CD-PEG degraded 1 week	67.79	0.88	31.33	-
CD-PEI	51.94	2.47	45.59	-
CD-PEI degraded 1 week	61.77	13.29	24.93	
CD-Lipid	72.97	1.01	26.02	-
CD-Lipid degraded 1 week	65.39	4.37	30.24	
CD-PO4	64.06	7.69	28.25	
CD-PO4 degraded 1 week	71.99	-	28.01	-

Table S1. Atomic percentages of CDs before and after subjecting to lipase-mediated biodegradation process.