

Catalytic and Capacitive Properties of Hierarchical Carbon Nickel Nanocomposites

Hassan H. Hammud ^{1,*}, Waleed A. Aljamhi ¹, Dolayl E. Al-Hudairi ¹, Nazish Parveen ^{1,*}, Sajid Ali Ansari ², Thirumurugan Prakasam ³

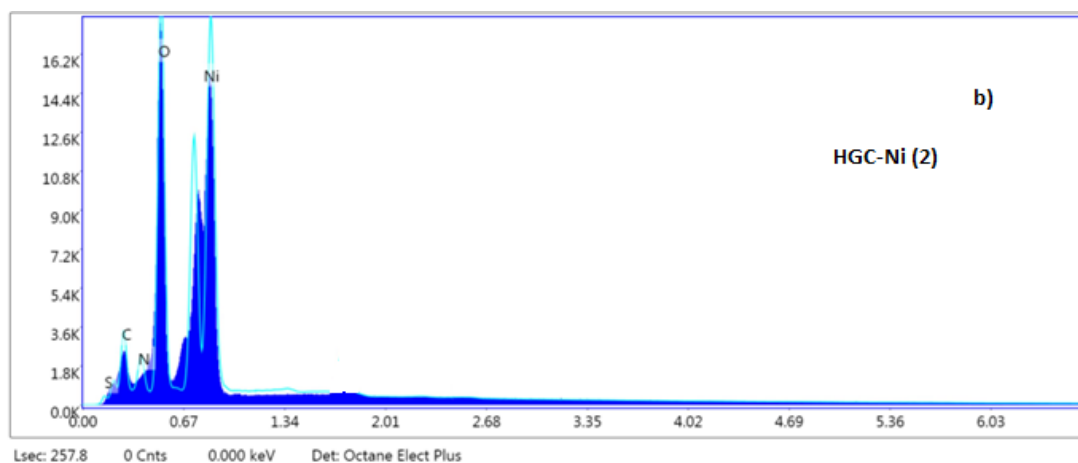
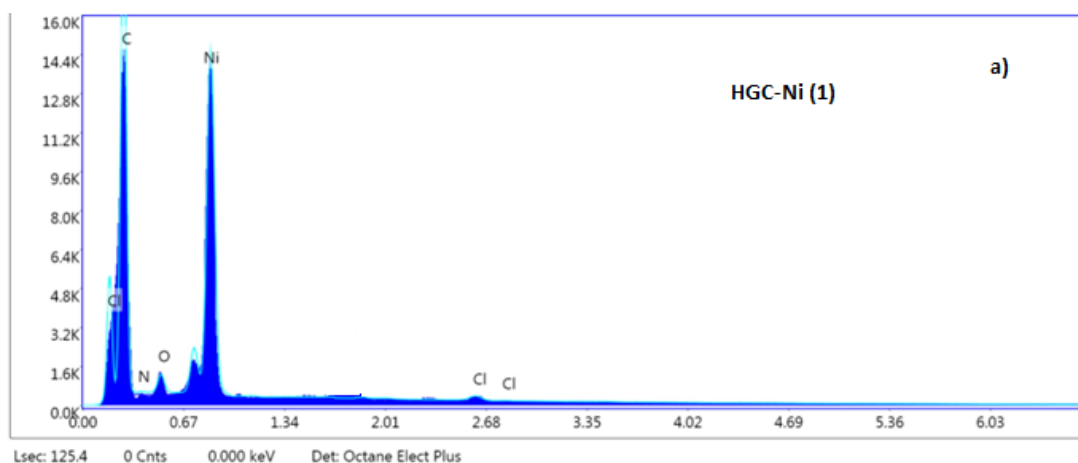
¹Department of Chemistry, College of Science, King Faisal University, Al-Ahsa 31982, Saudi Arabia

²Department of Physics, College of Science, King Faisal University, Al-Ahsa, 31982, Saudi Arabia

³New York University Abu Dhabi (NYUAD), Abu Dhabi, United Arab Emirates

Correspondence: hhammoud@kfu.edu.sa (H.H.H); nislam@kfu.edu.sa (N.P)

Supplementary



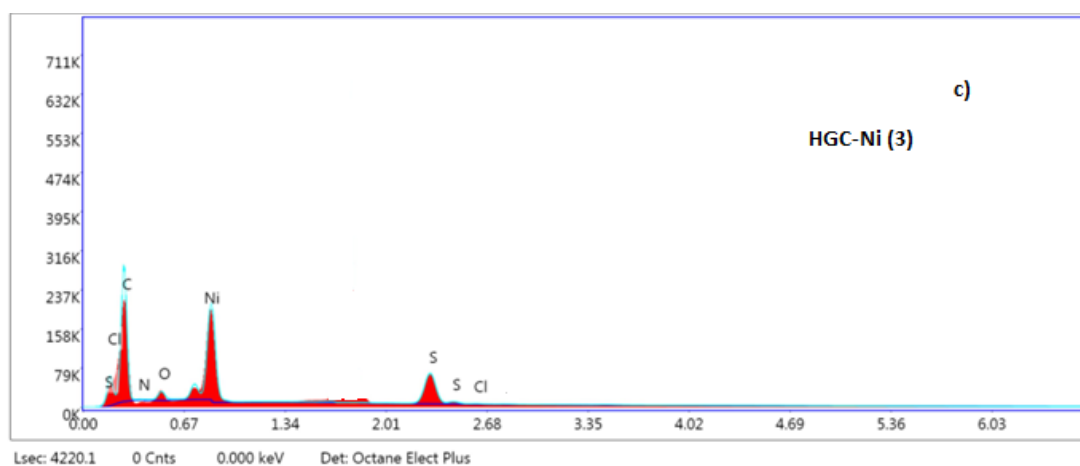
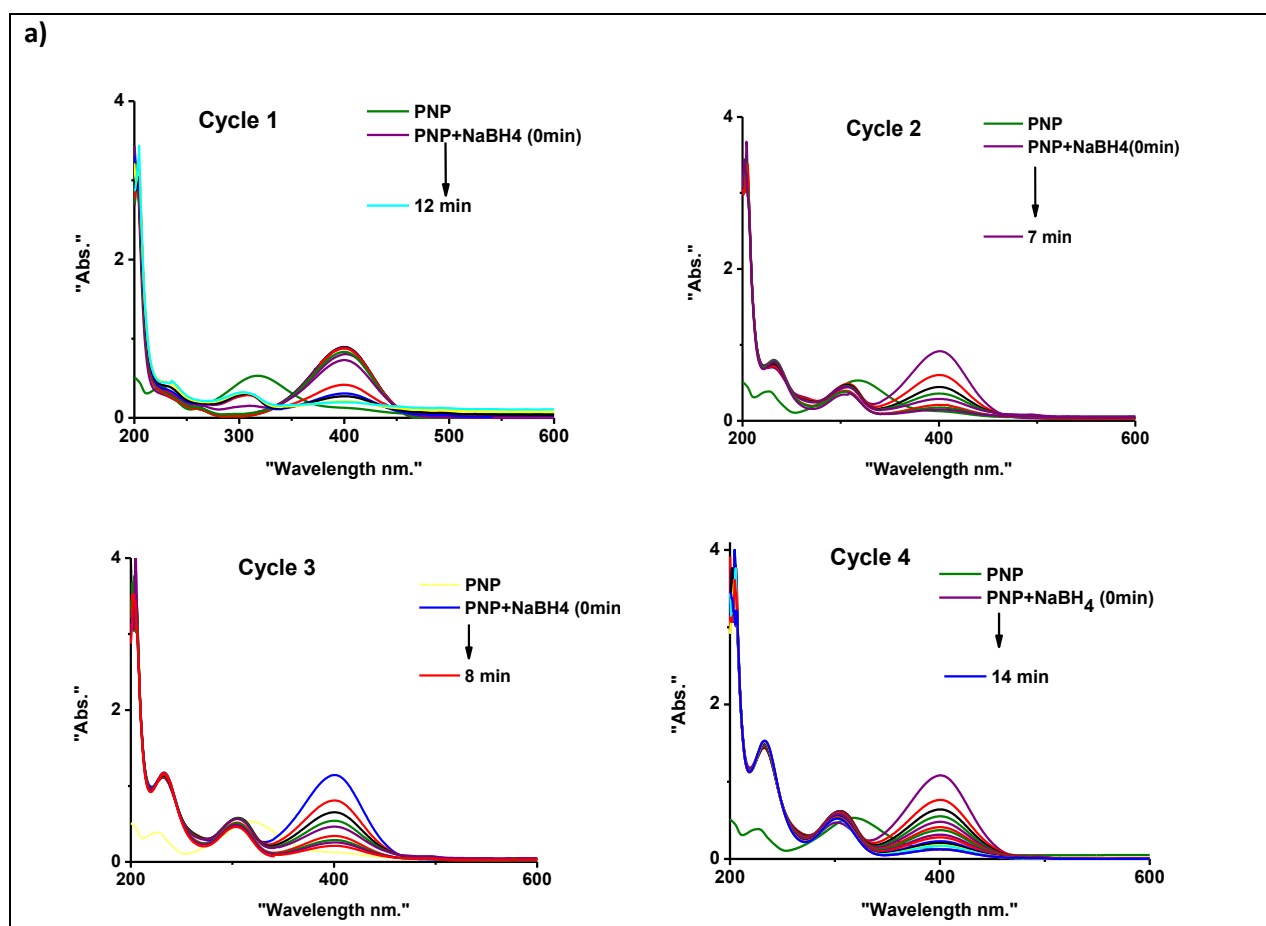
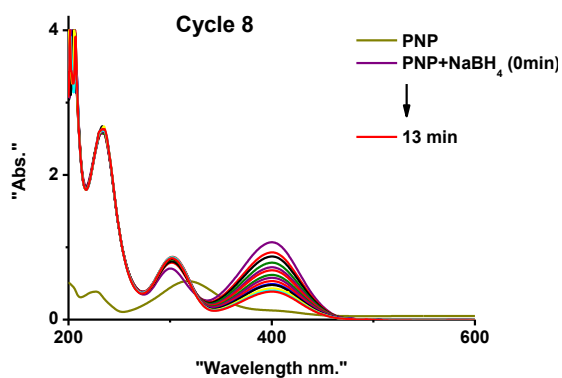
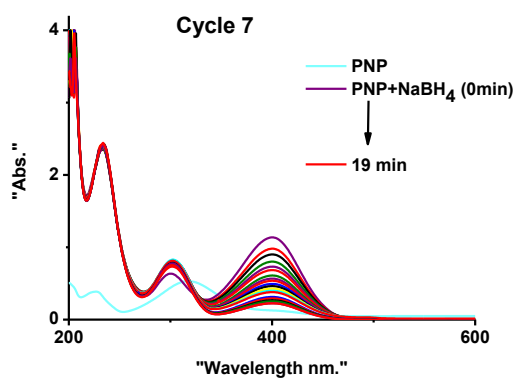
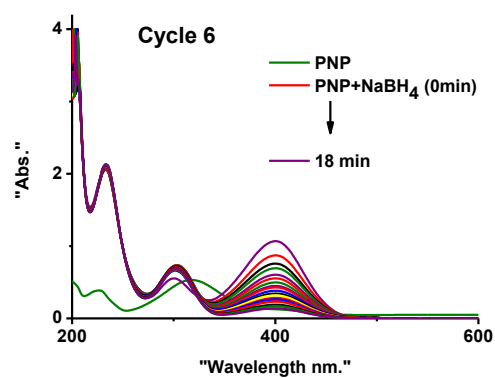
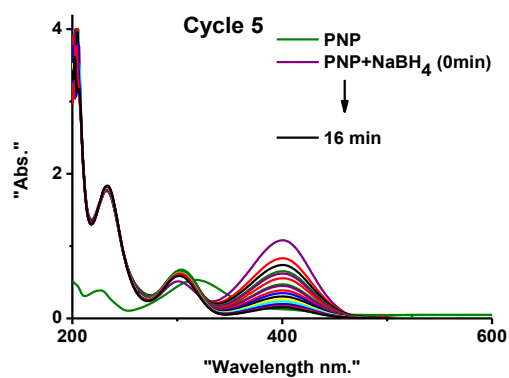
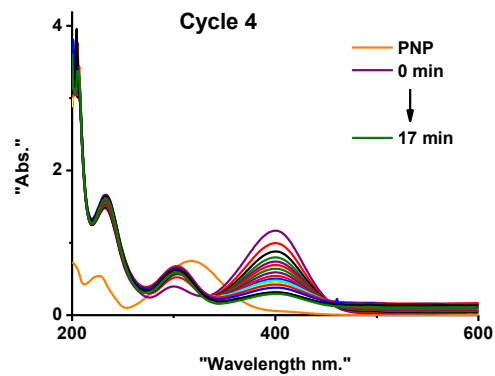
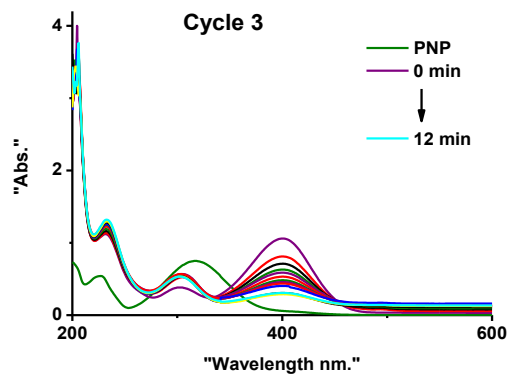
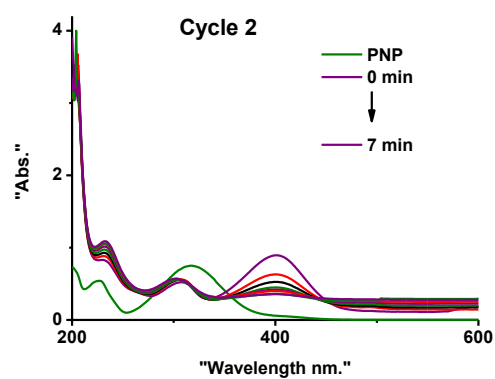
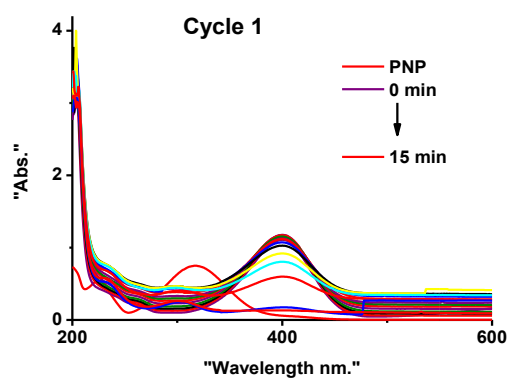


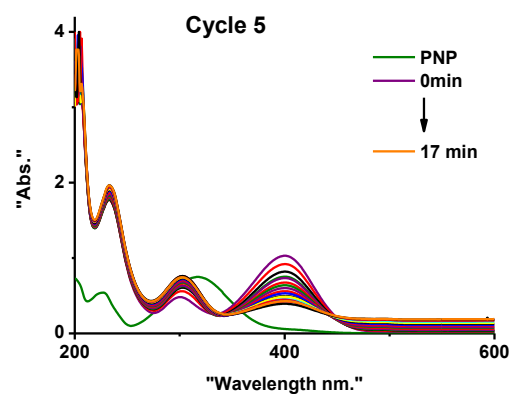
Fig. S 1. EDAX of a) HGC-Ni (1), b) HGC-Ni (2) and c) HGC-Ni (3) nanocomposites.



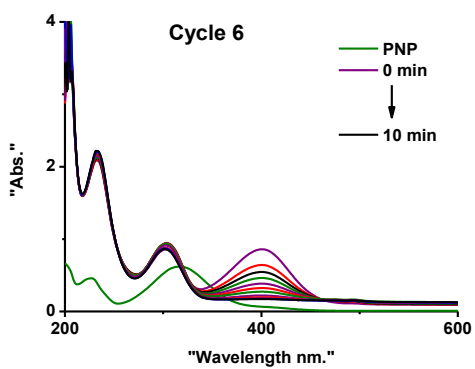
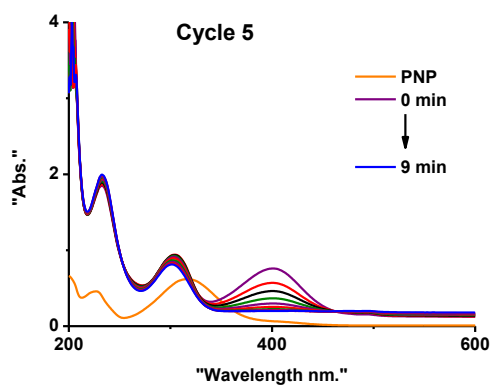
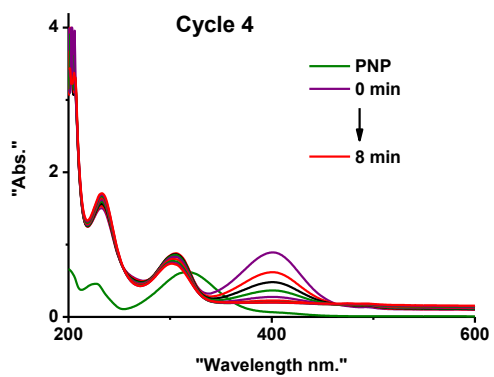
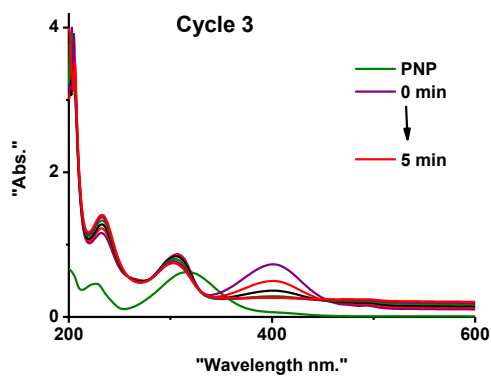
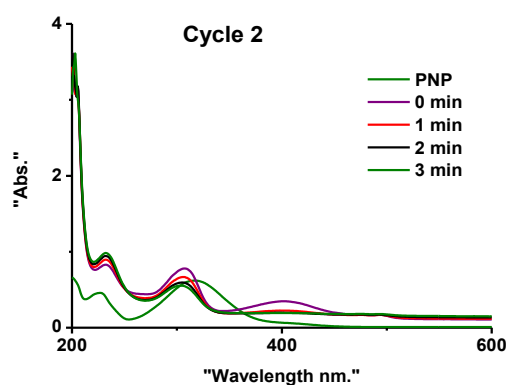
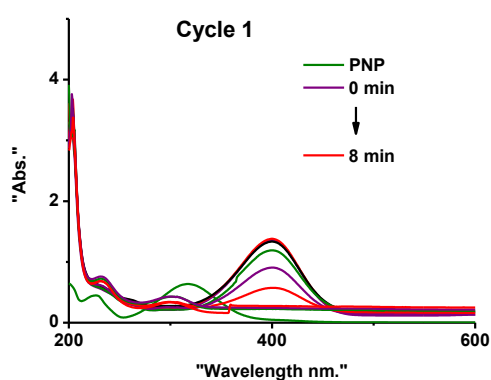


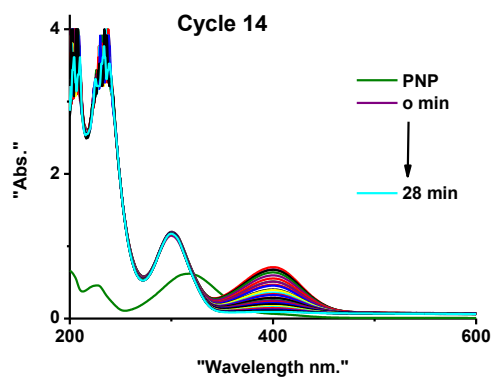
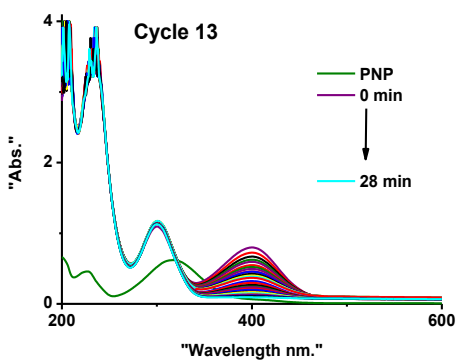
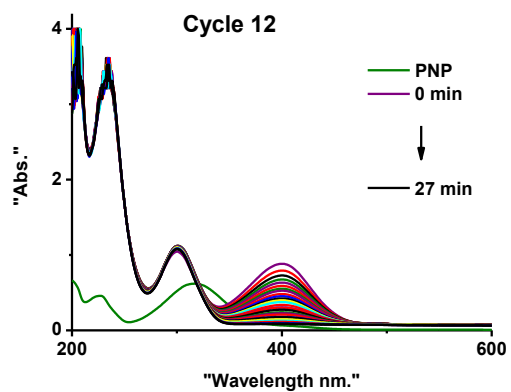
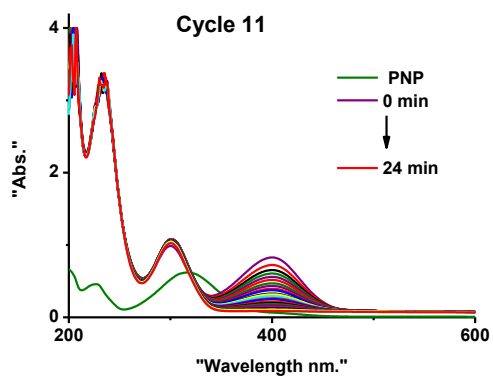
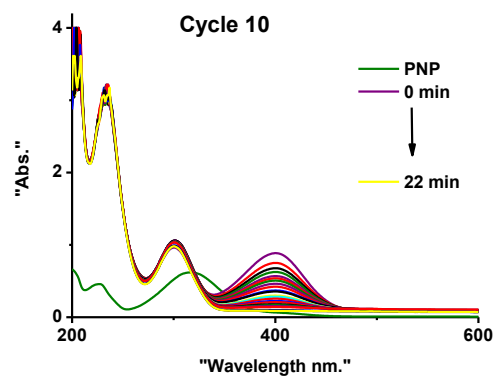
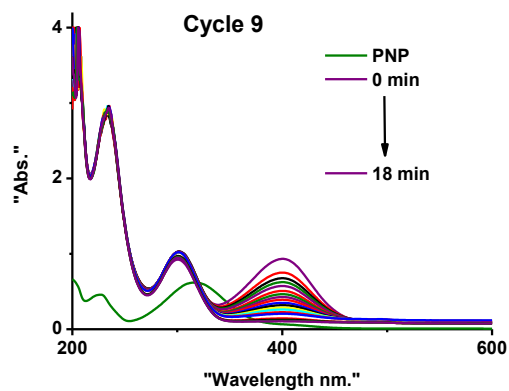
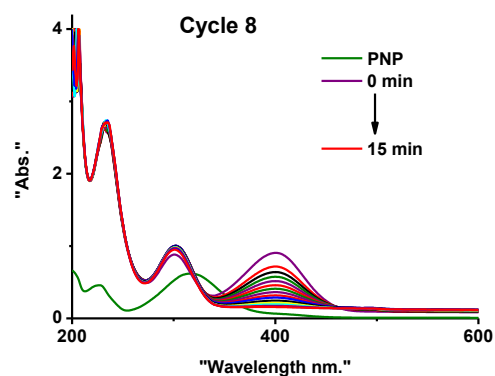
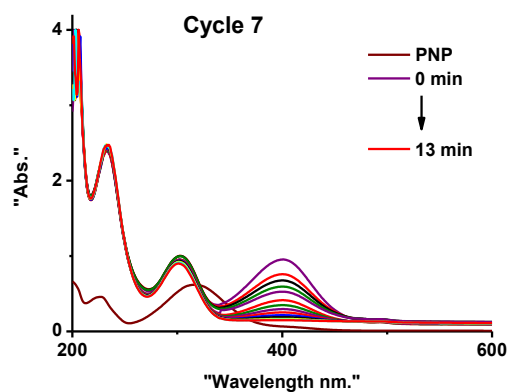
b)





(c)





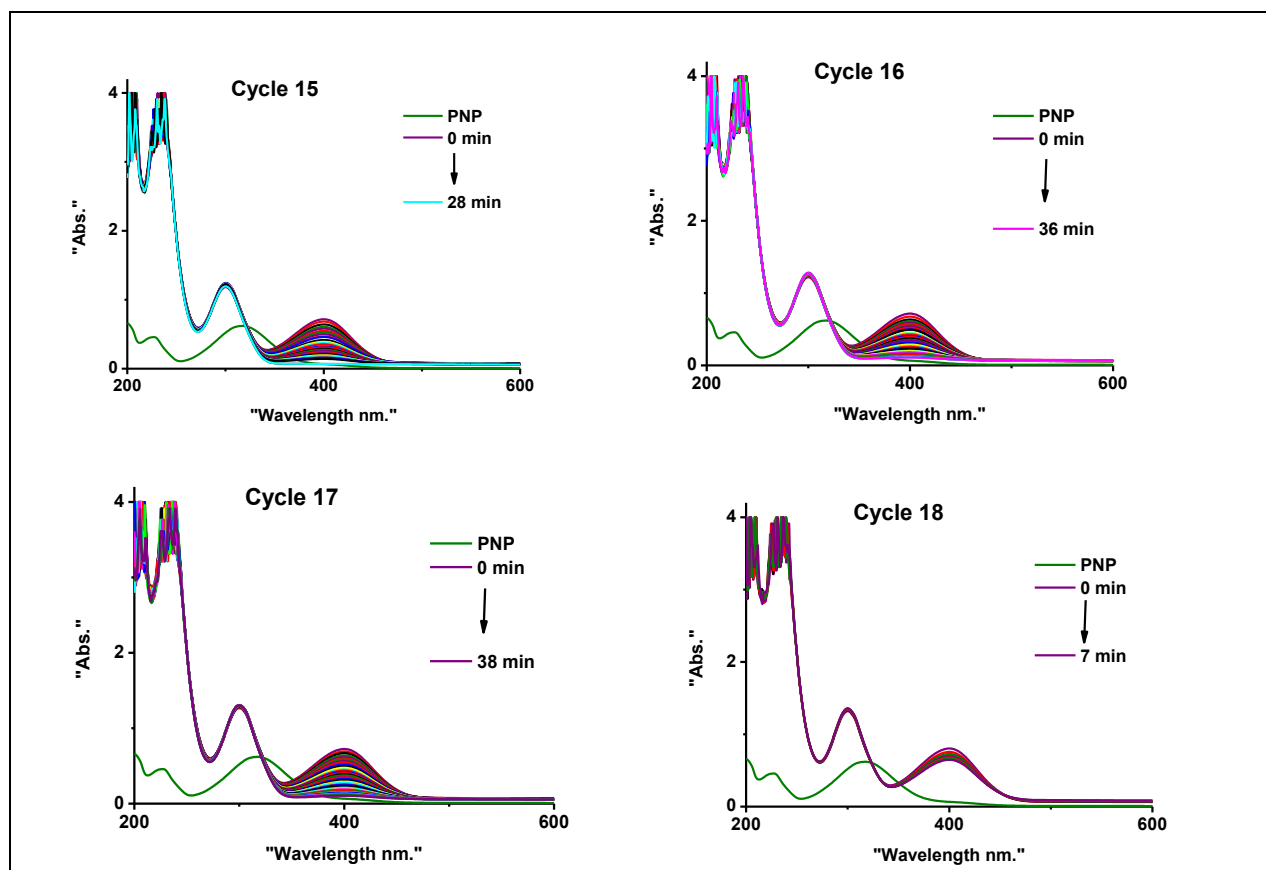


Fig. S 2. Progress of UV-Vis spectra at different cycles for reduction of 4-nitrophenol by HGC-Ni a) (1), b) (2), and c) (3) nano-catalysts.

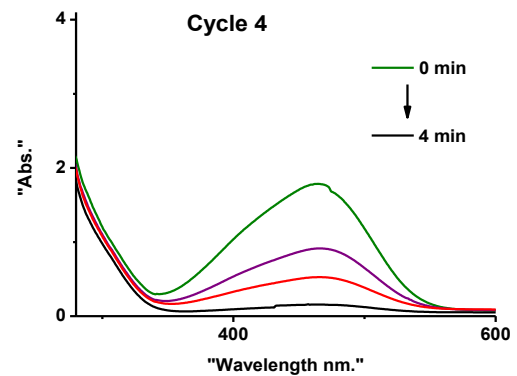
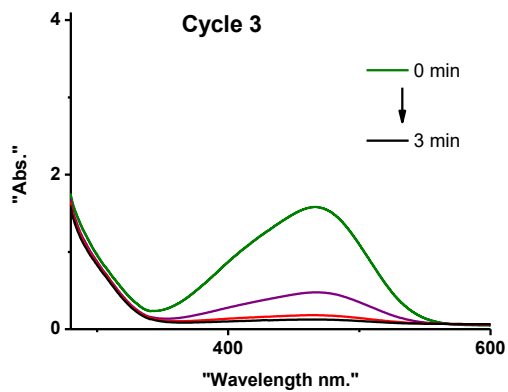
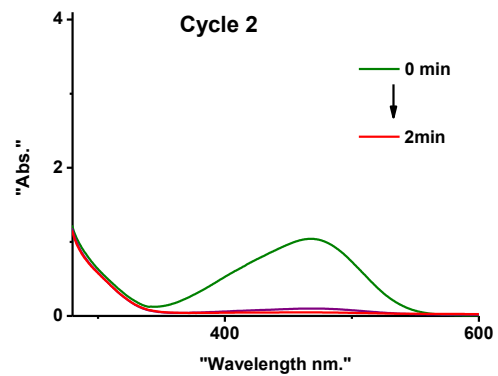
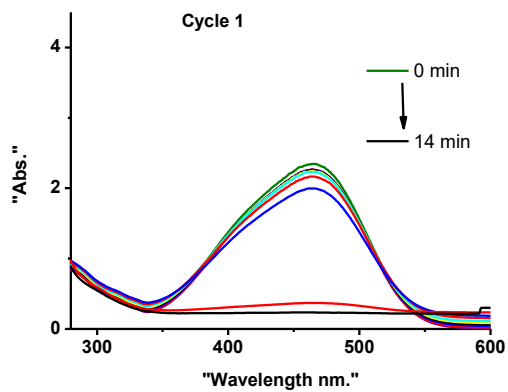
Table S 1. Catalytic reduction of the P-NP by HGC-Ni (1), (2), and (3) nano-catalysts. Using 0.2 mg nanocatalyst, 4 mg NaBH₄, and water 2.5ml. A 0.1ml of 0.28 mg/ml stock P-NP was added in each cycle.

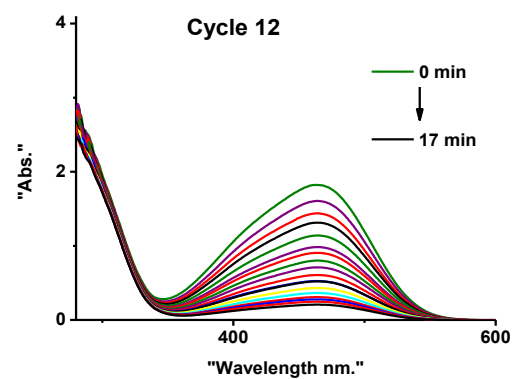
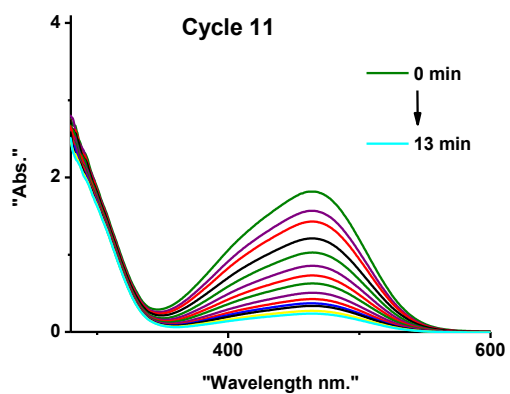
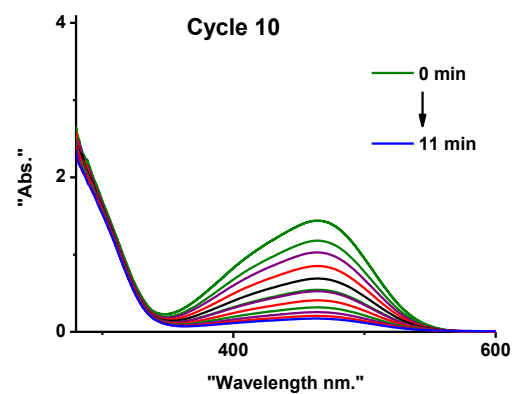
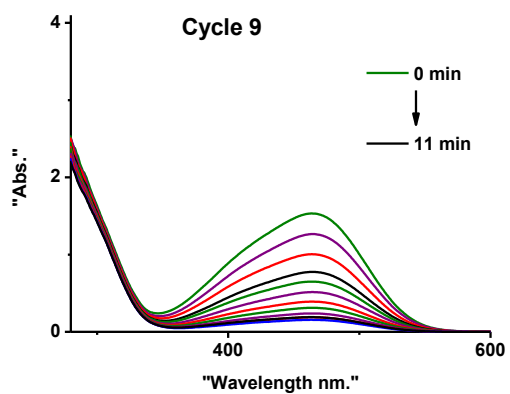
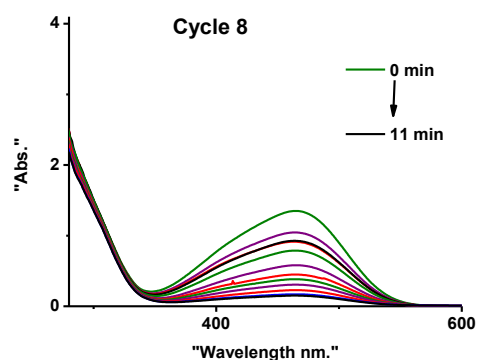
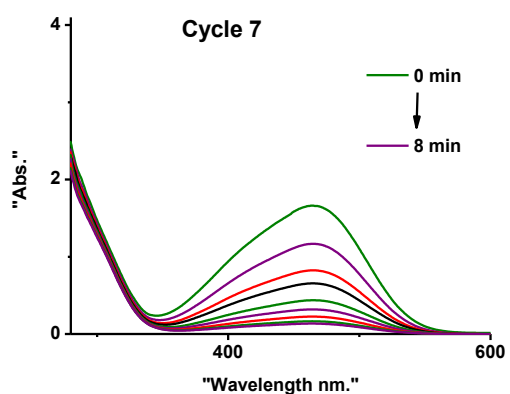
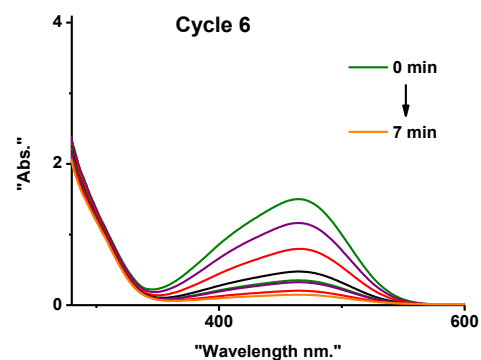
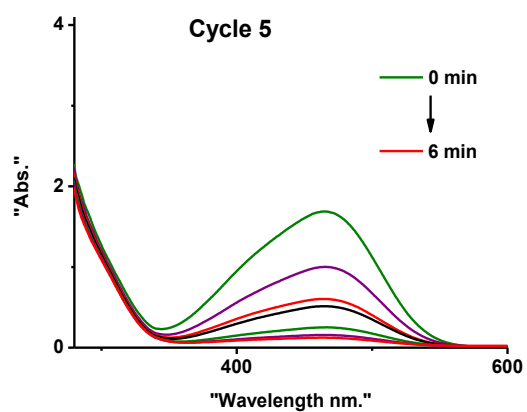
Catalyst	P-NP (C=0.28mg/ml) mL (mg)	No.of cycles	Duration of cycle (min)	First order rate constant		Turn over number TON mg P-NP/mg nano (mmol PNP /mg nano)	Turn over frequency TOF (mg P-NP /mg nano)/min (mmol PNP /mg nano)/min
				k	R ²		
(1)	0.1ml (0.028 mg)	Cycle1	12 min	0.1389	0.794	1.0682 (0.00768)	0.0098 (7.045 x10 ⁻⁵)
	0.1ml (0.028 mg)	Cycle2	7 min	0.2552	0.9854		
	0.1ml (0.028 mg)	Cycle3	10 min	0.2122	0.9928		
	0.1ml (0.028 mg)	Cycle4	14 min	0.1471	0.9898		
	0.1ml	Cycle5	16 min	0.1173	0.9947		

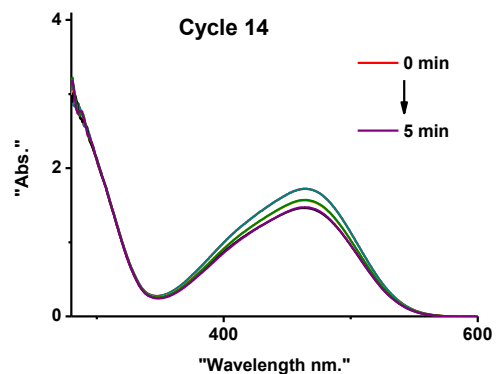
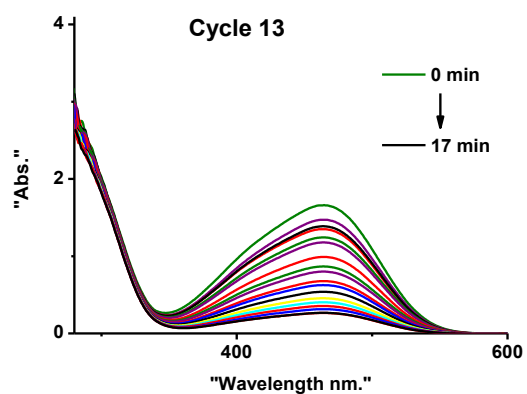
	(0.028 mg)						
	0.1ml (0.028 mg)	Cycle6	18 min	0.1011	0.9898		
	0.1ml (0.028 mg)	Cycle7	19 min	0.0842	0.995		
	0.1ml (0.028 mg)	Cycle8	13 min	0.0769	0.9931		
	Total = 0.8ml (0.224 mg)	Total = 7.63 cycles	Total = 109 min				
(2)	0.1ml (0.028 mg)	Cycle1	15 min	0.1025	0.5091	0.6412 (0.004609)	0.0094294 (6.778 x10 ⁻⁵)
	0.1ml (0.028 mg)	Cycle2	7 min	0.1847	0.9296		
	0.1ml (0.028 mg)	Cycle3	12 min	0.1039	0.9661		
	0.1ml (0.028 mg)	Cycle4	17 min	0.075	0.9766		
	0.1ml (0.028 mg)	Cycle5	17 min only 58% complete	0.0567	0.9731		
	Total = 0.5ml (0.14mg)	Total = 4.58 cycles	Total = 68 min				
(3)	0.1ml (0.028 mg)	Cycle1	8 min	0.2644	0.8504	2.4066 (0.017299)	0.007409 (5.326 x10 ⁻⁵)
	0.1ml (0.028 mg)	Cycle2	3 min	0.2831	0.9142		
	0.1ml (0.028 mg)	Cycle3	5 min	0.3113	0.9897		
	0.1ml (0.028 mg)	Cycle4	8 min	0.2723	0.9937		
	0.1ml (0.028 mg)	Cycle5	9 min	0.2044	0.9873		
	0.1ml (0.028 mg)	Cycle6	10 min	0.1749	0.9927		
	0.1ml (0.028 mg)	Cycle7	13 min	0.1563	0.9945		
	0.1ml (0.028 mg)	Cycle8	15 min	0.1182	0.9941		
	0.1ml (0.028 mg)	Cycle9	18 min	0.1014	0.9958		
	0.1ml (0.028 mg)	Cycle10	22 min	0.0949	0.9963		
	0.1ml (0.028 mg)	Cycle11	24 min	0.0896	0.9968		

	0.1ml (0.028 mg)	Cycle12	27 min	0.0729	0.9964		
	0.1ml (0.028 mg)	Cycle13	28 min	0.0751	0.9873		
	0.1ml (0.028 mg)	Cycle14	28 min	0.0655	0.99		
	0.1ml (0.028 mg)	Cycle15	28 min	0.0613	0.9955		
	0.1ml (0.028 mg)	Cycle16	36 min	0.042	0.9942		
	0.1ml (0.028 mg)	Cycle17	36 min	0.0434	0.9929		
	0.1ml (0.028 mg)	Cycle18	7 min only 19 % complete	0.0285	0.9619		
	Total = 1.8 ml (0.504mg)	Total = 17.19 cycles	Total = 325 min				

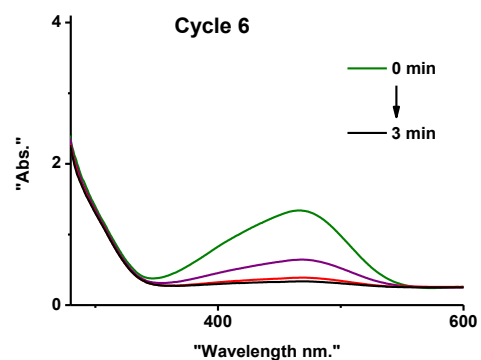
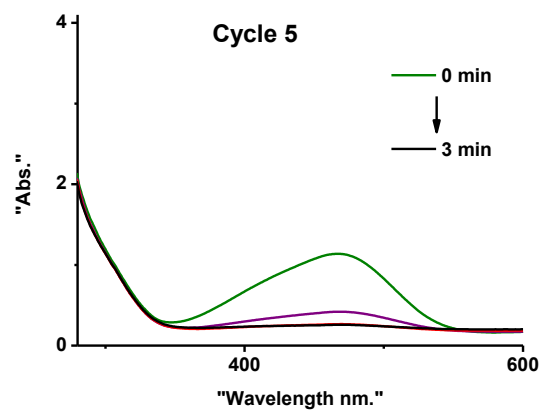
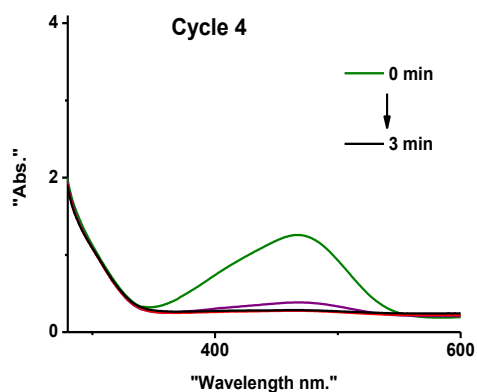
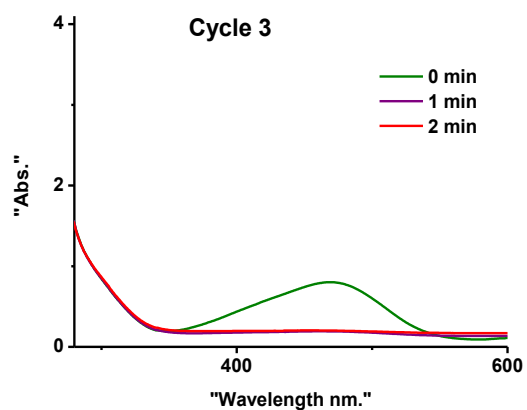
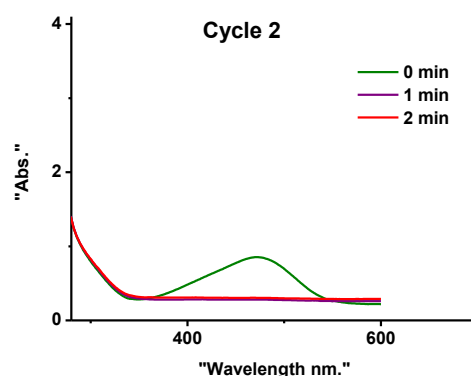
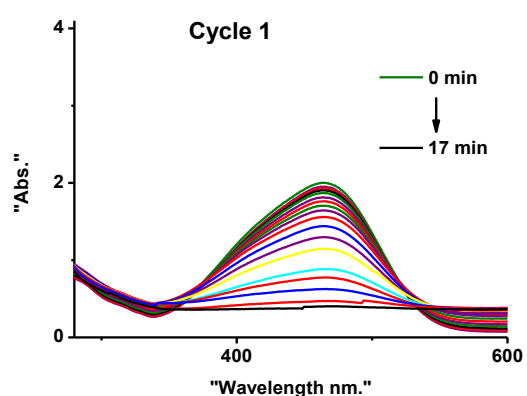
a)

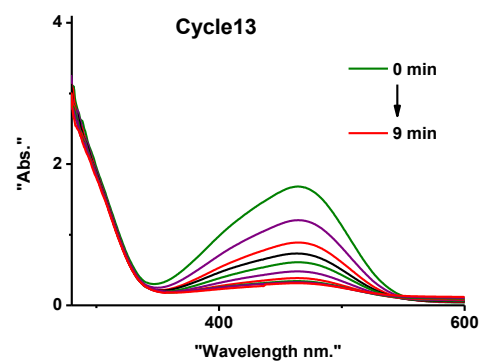
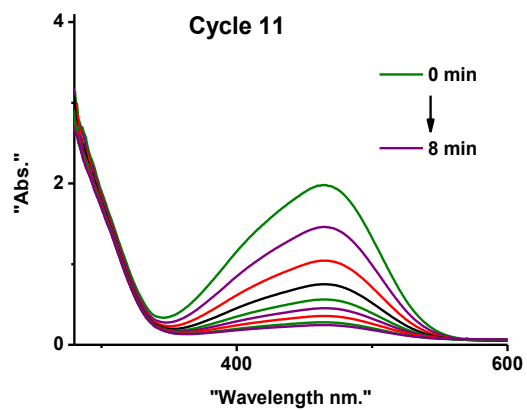
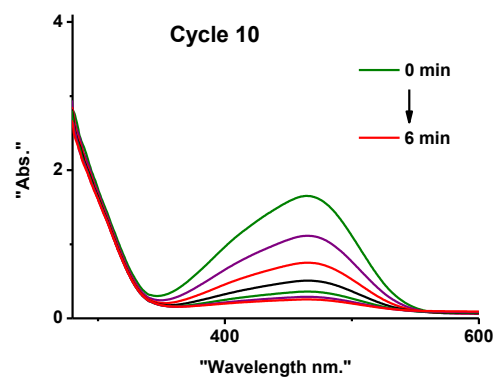
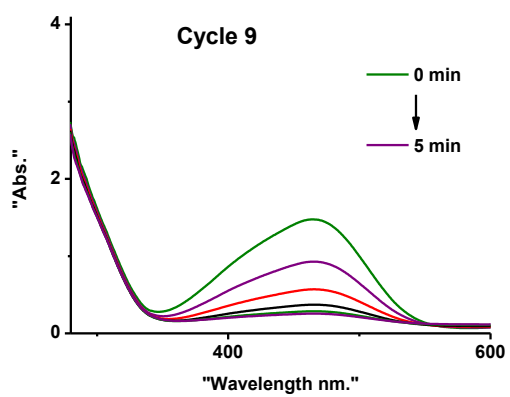
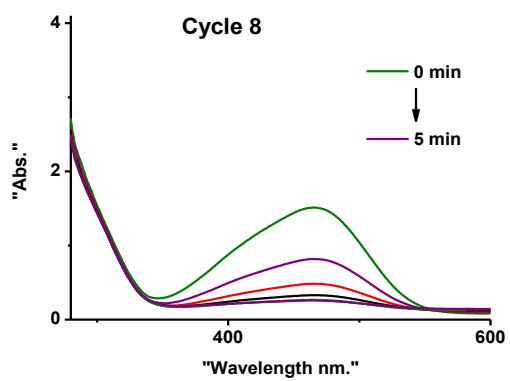
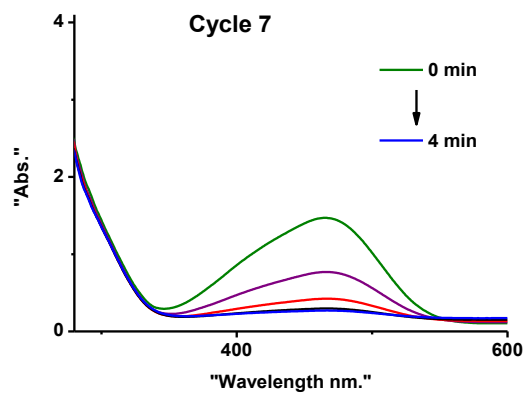


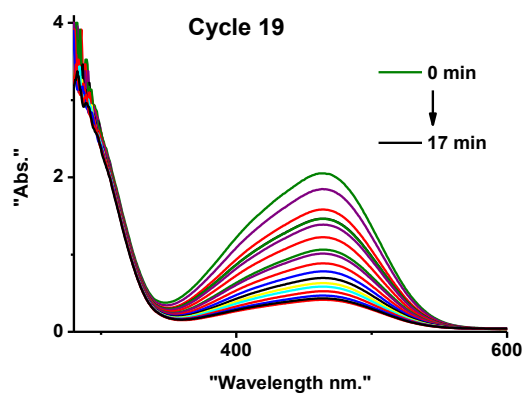
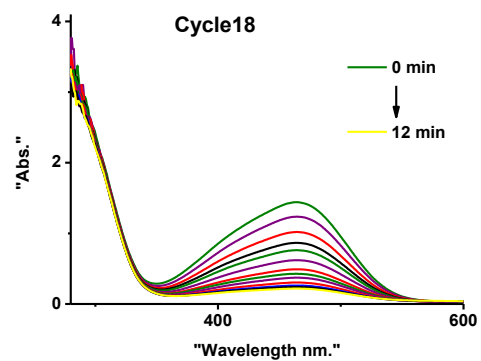
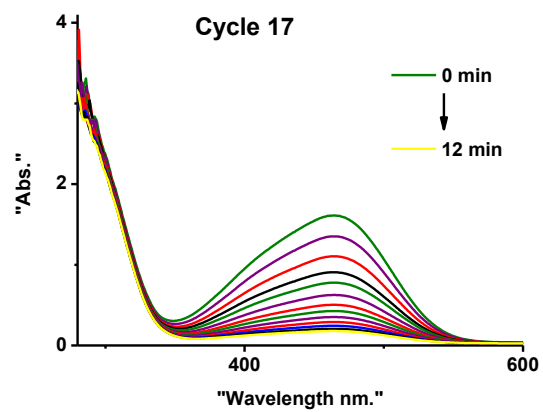
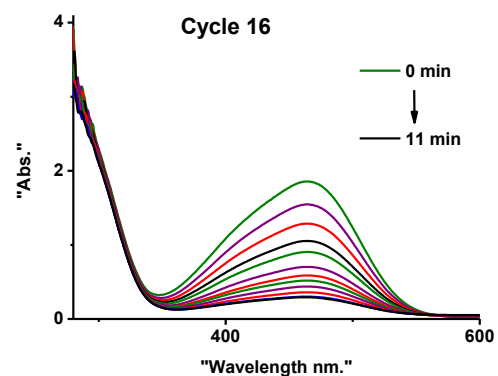
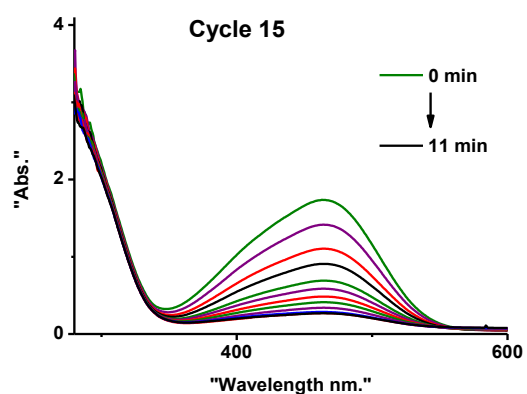
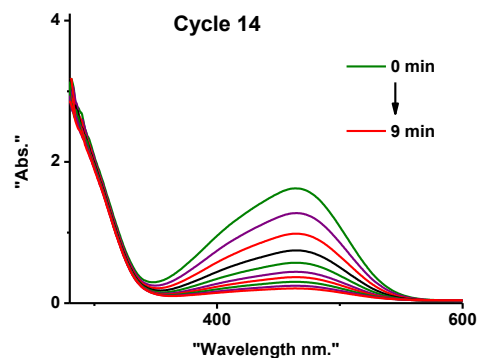
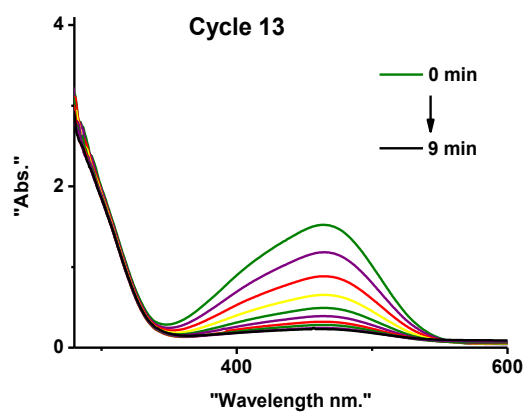




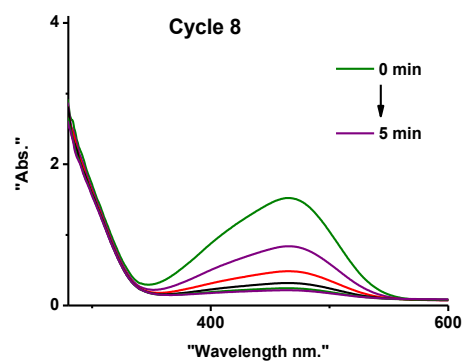
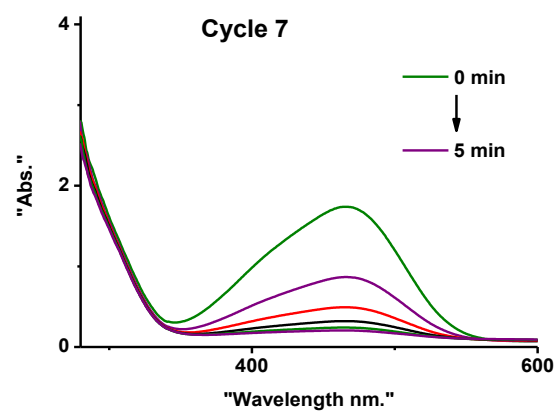
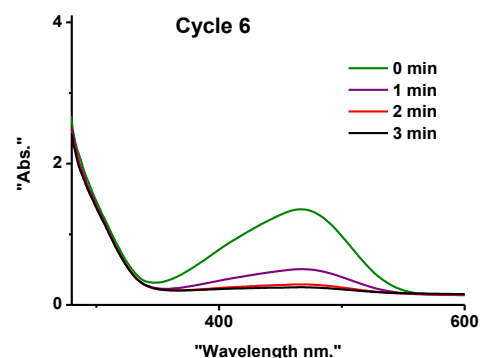
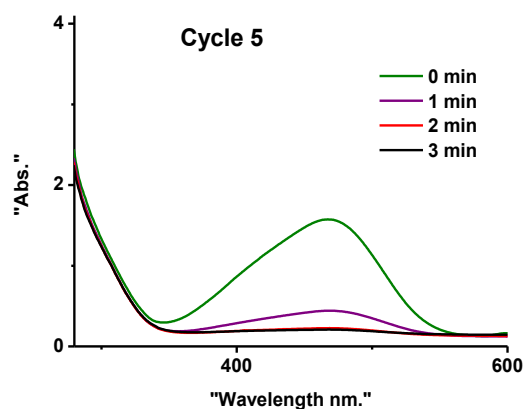
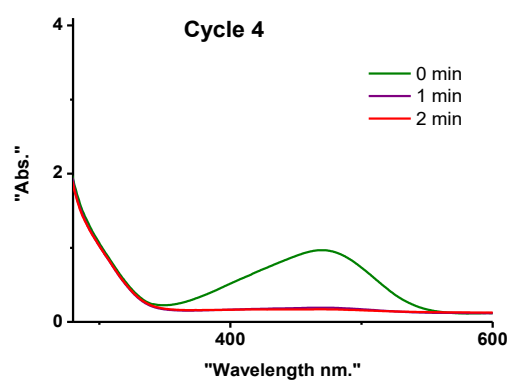
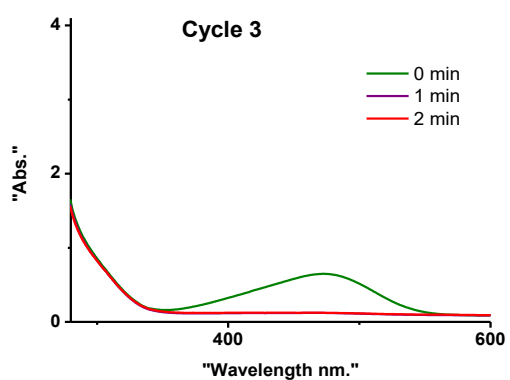
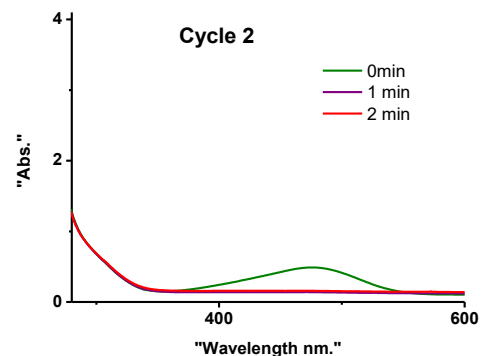
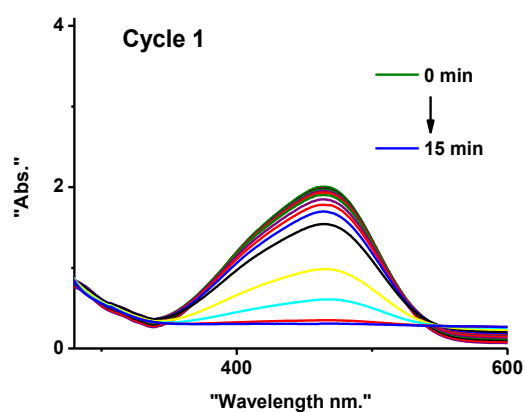
b)

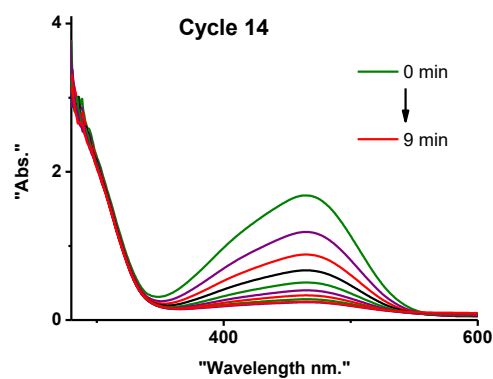
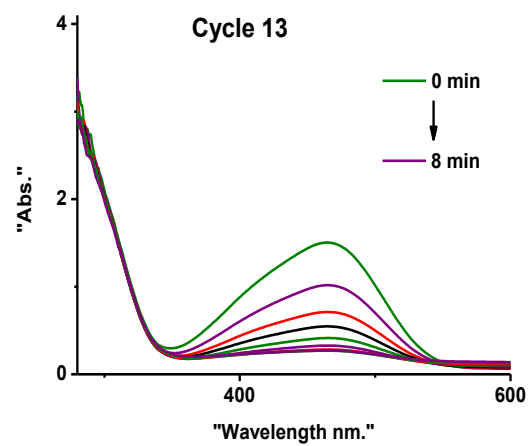
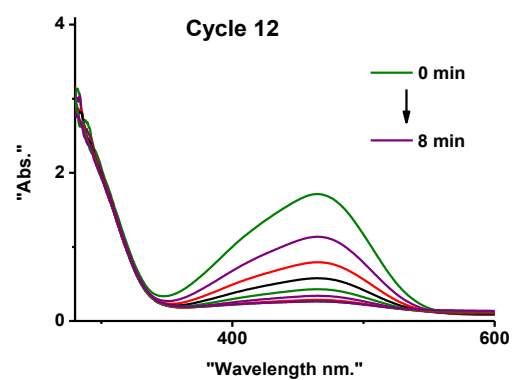
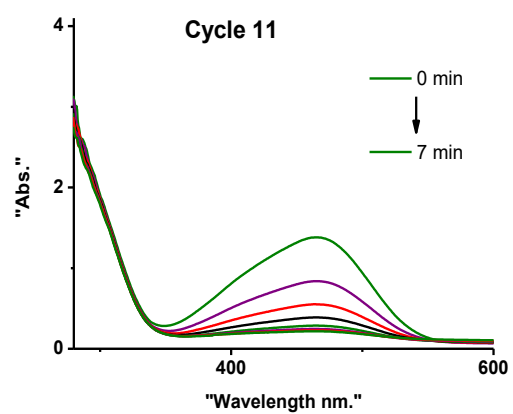
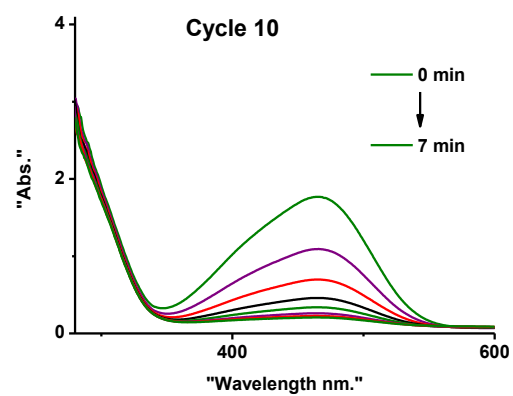
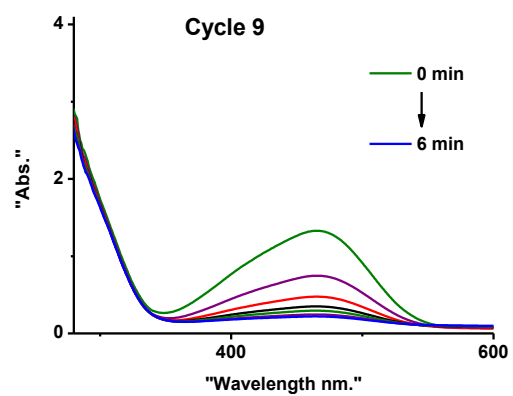


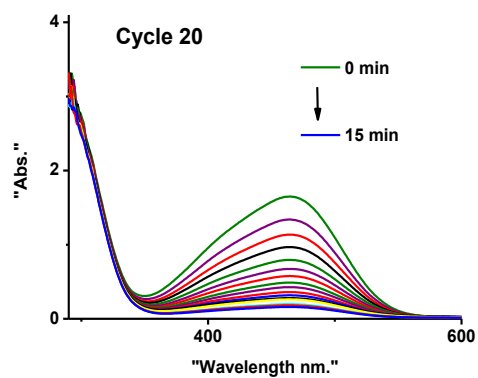
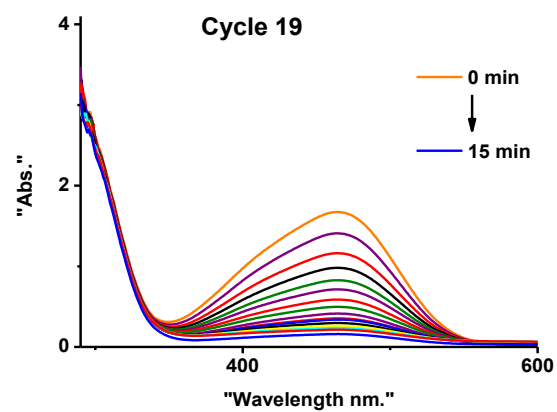
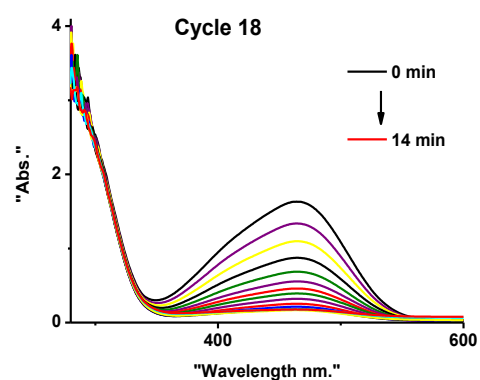
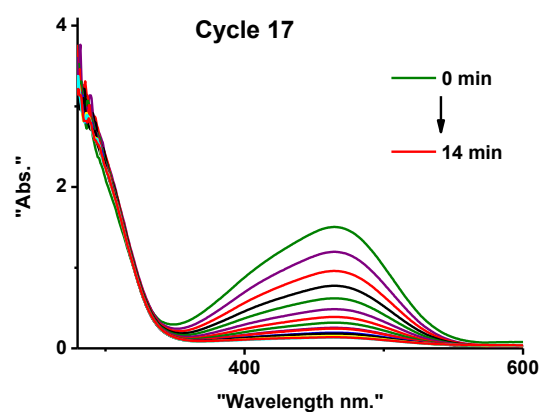
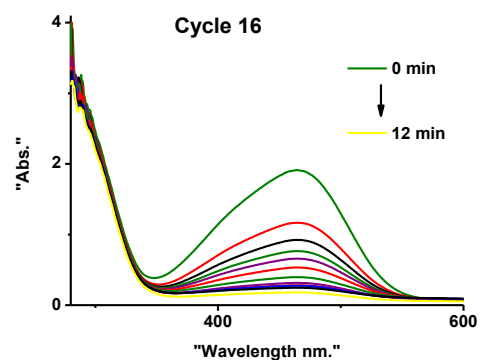
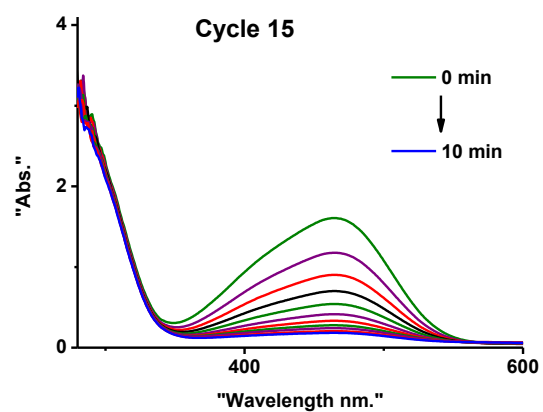




c)







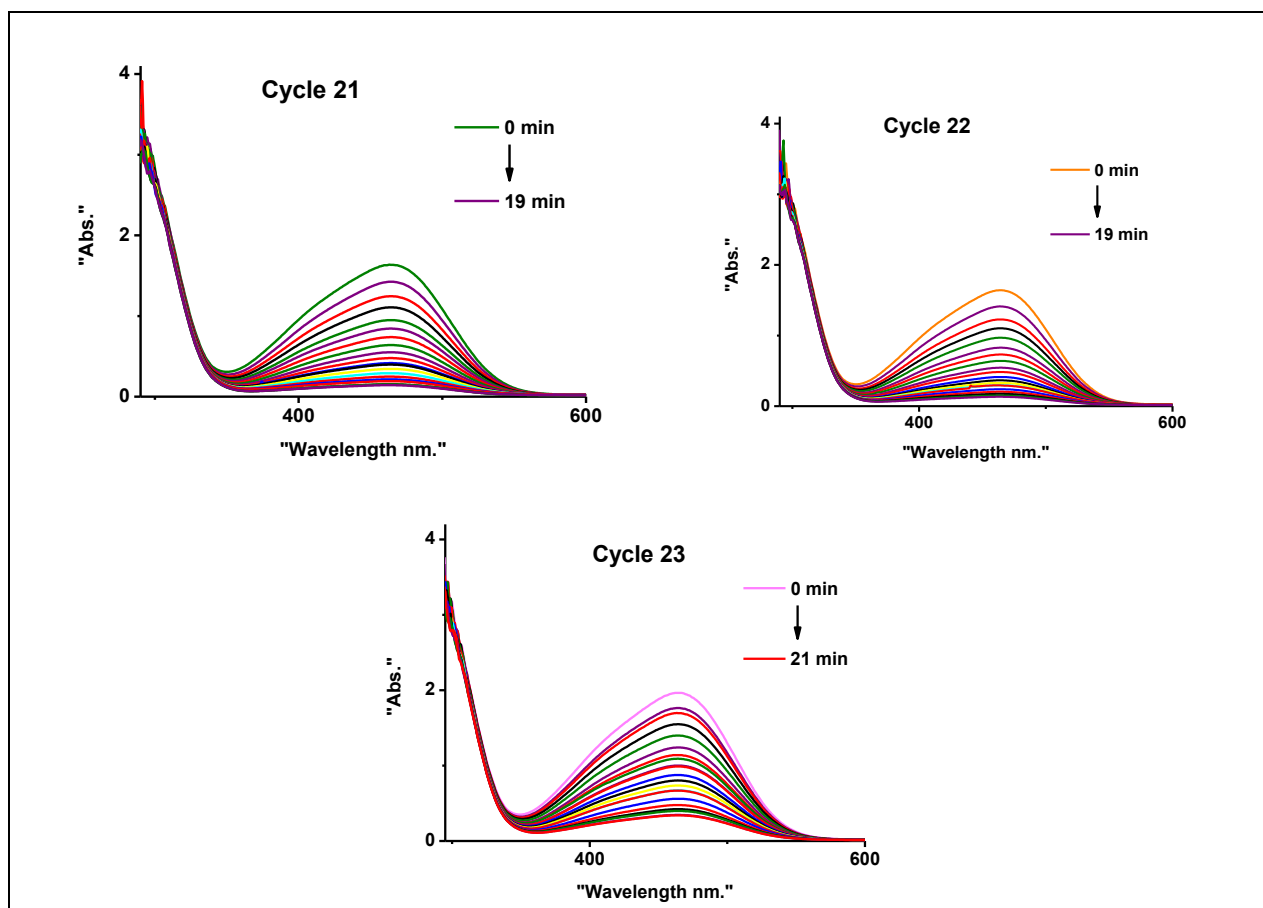


Fig S 3. Progress of UV-Vis spectra at different cycles for reduction of MO by HGC-Ni a) (1), b) (2), and c) (3) nano-catalysts.

Table S 2. Catalytic reduction of the P-NP by HGC-Ni (1), (2), and (3) nano-catalysts. Using 0.2 mg nanocatalyst, 4 mg NaBH₄, and water 2.5ml. A 0.05 ml of 1.28 mg/ml stock MO was added in each cycle.

Catalyst	MO (C= 1.28mg/ml) mL (mg)	No.of cycles	Duration of cycle (min)	First order rate constant		Turn over number TON mg MO/mg nano (mmol MO /mg nano)	Turn over frequency TOF (mg MO /mg nano)/min (mmol MO /mg nano)/min
				k	R ²		
(1)	0.05 ml (0.064 mg)	Cycle1	14 min	0.1432	0.6345	4.448 (0.013588)	0.03475 (1.0616x10 ⁻⁴)
	0.05 ml (0.064 mg)	Cycle2	2 min	1.5281	0.9136		
	0.05 ml (0.064 mg)	Cycle3	3 min	0.8579	0.9536		
	0.05 ml (0.064 mg)	Cycle4	4 min	0.5926	0.9965		
	0.05 ml	Cycle5	6 min	0.4434	0.9864		

	(0.064 mg)						
	0.05 ml (0.064 mg)	Cycle6	7 min	0.3325	0.987		
	0.05 ml (0.064 mg)	Cycle7	8 min	0.3204	0.9973		
	0.05 ml (0.064 mg)	Cycle8	11 min	0.2034	0.9791		
	0.05 ml (0.064 mg)	Cycle9	11 min	0.2337	0.9988		
	0.05 ml (0.064 mg)	Cycle10	11 min	0.1935	0.9953		
	0.05 ml (0.064 mg)	Cycle11	13 min	0.1608	0.9978		
	0.05 ml (0.064 mg)	Cycle12	17 min	0.1266	0.9968		
	0.05 ml (0.064 mg)	Cycle13	17 min	0.1154	0.9863		
	0.05 ml (0.064 mg)	Cycle14	4 min only 9.% complete	0.0816	0.991		
	Total = 0.7ml (0.896 mg)	Total = 13.9 cycles	Total =128 min				
(2)	0.05 ml (0.064 mg)	Cycle1	17 min	0.088	0.8284	5.6928 (0.017391)	0.03846486 (1.175x10 ⁻⁴)
	0.05 ml (0.064 mg)	Cycle2	2 min	0.5119	0.6929		
	0.05 ml (0.064 mg)	Cycle3	2 min	0.6863	0.7224		
	0.05 ml (0.064 mg)	Cycle4	3 min	0.7566	0.9028		
	0.05 ml (0.064 mg)	Cycle5	3 min	0.7286	0.9561		
	0.05 ml (0.064 mg)	Cycle6	3 min	0.6206	0.9891		
	0.05 ml (0.064 mg)	Cycle7	4 min	0.5408	0.9845		
	0.05 ml (0.064 mg)	Cycle8	5 min	0.4388	0.9674		
	0.05 ml (0.064 mg)	Cycle9	5 min	0.4199	0.9892		
	0.05 ml (0.064 mg)	Cycle10	6 min	0.3564	0.9923		
	0.05 ml (0.064 mg)	Cycle11	8 min	0.2803	0.9937		
	0.05 ml (0.064 mg)	Cycle12	9 min	0.2073	0.9729		

	0.05 ml (0.064 mg)	Cycle13	9 min	0.2362	0.9827		
	0.05 ml (0.064 mg)	Cycle14	9 min	0.2317	0.9939		
	0.05 ml (0.064 mg)	Cycle15	11 min	0.2043	0.9968		
	0.05 ml (0.064 mg)	Cycle16	11 min	0.1818	0.9982		
	0.05 ml (0.064 mg)	Cycle17	12 min	0.187	0.999		
	0.05 ml (0.064 mg)	Cycle18	12 min	0.1643	0.9945		
	0.05 ml (0.064 mg)	Cycle19	17 min Only 79 % complete	0.0983	0.9924		
	Total = 0.95ml (1.216 mg)	Total = 18.79 cycles	Total = 148 min				
(3)	0.05 ml (0.064 mg)	Cycle1	15 min	0.1068	0.6341	7.3024 (0.022308)	0.0331927 (1.014x10 ⁻⁴)
	0.05 ml (0.064 mg)	Cycle2	2 min	0.5546	0.6644		
	0.05 ml (0.064 mg)	Cycle3	2 min	0.8214	0.7388		
	0.05 ml (0.064 mg)	Cycle4	2 min	0.8682	0.8023		
	0.05 ml (0.064 mg)	Cycle5	3 min	0.9701	0.9692		
	0.05 ml (0.064 mg)	Cycle6	3 min	0.7705	0.9745		
	0.05 ml (0.064 mg)	Cycle7	5 min	0.4945	0.9741		
	0.05 ml (0.064 mg)	Cycle8	5 min	0.463	0.9793		
	0.05 ml (0.064 mg)	Cycle9	6 min	0.3303	0.9426		
	0.05 ml (0.064 mg)	Cycle10	7 min	0.3483	0.9712		
	0.05 ml (0.064 mg)	Cycle11	7 min	0.3484	0.9734		
	0.05 ml (0.064 mg)	Cycle12	8 min	0.3003	0.984		
	0.05 ml (0.064 mg)	Cycle13	8 min	0.2792	0.9819		
	0.05 ml (0.064 mg)	Cycle14	9 min	0.2431	0.9838		
	0.05 ml	Cycle15	10 min	0.2192	0.9828		

	(0.064 mg)						
	0.05 ml (0.064 mg)	Cycle16	12 min	0.1911	0.9844		
	0.05 ml (0.064 mg)	Cycle17	14 min	0.1887	0.9852		
	0.05 ml (0.064 mg)	Cycle18	14 min	0.1965	0.9958		
	0.05 ml (0.064 mg)	Cycle19	14 min	0.1586	0.9936		
	0.05 ml (0.064 mg)	Cycle20	15 min	0.154	0.9957		
	0.05 ml (0.064 mg)	Cycle21	19 min	0.1331	0.9974		
	0.05 ml (0.064 mg)	Cycle22	19 min	0.1298	0.9974		
	0.05 ml (0.064 mg)	Cycle23	21 min only82.7% complete	0.0852	0.9878		
	Total = 1.15 ml (1.472mg)	Total = 22.82 cycles	Total = 220 min				