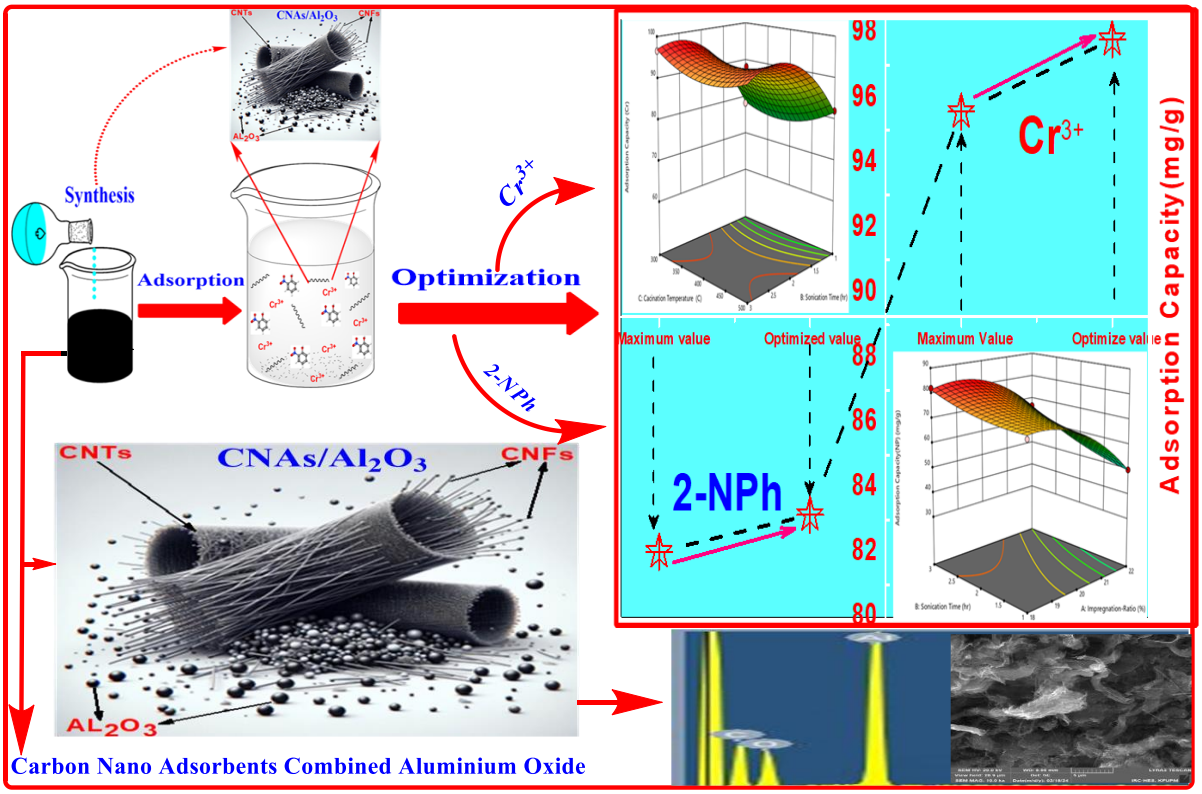
GRAPHICAL ABSTRACT



Appendix A-1:

Table .1. Quantity of Aluminum Loaded on the Carbon Nano Adsorbents

SN	Mass of CNAs (mg)	Desired (%) of Aluminium	Mass need from Aluminium (mg)	Formula for calculation Mw Al $(No_3)_3$ = 375.13(g/mole) Atomic weight of Al = 26.981 (g/mole) $\frac{Mw\ of\ Al(NO3)3}{x} = \frac{Atomic\ W\ of\ Al}{wight\ of\ Al(mg)}$	Quantity collected from Aluminium Nitrate (mg).
1	200	18%	36	$\frac{375.13}{x} = \frac{26.981}{36}$	500.52
2	200	20%	40	$\frac{375.13}{x} = \frac{26.981}{40}$	556.13
3	200	22 %	44	$\frac{375.13}{x} = \frac{26.981}{44}$	611.75
4	200	19% *(Validation step)*	38	$\frac{375.13}{x} = \frac{26.981}{38}$	528.33

Appendix A-2:

Table .3. The Calculation of the Adsorption Capacity of CNAs/Al_2O_3 for 2-NPh.

Run Number	Ratio of Al %	Sonication Time	Calcination-Temp(°C)	Abs (50ppm=1.27125)	Equilibrium Con(ppm)	Qe (mg/g) of 2-NP
1	20	2	500	0.982526	38.6441	56.7795
2	18	1	500	0.90858	35.7357	71.3215
3	18	1	300	0.90298	35.5154	72.4228
4	18	2	400	0.909546	35.7737	71.1316
5	20	2	300	0.900419	35.4147	72.9265
6	20	2	400	0.939262	36.9425	65.2877
7	18	3	500	0.961478	37.8162	60.9188
8	22	2	400	1.041038	40.9454	45.2728
9	22	3	500	1.076546	42.342	38.2899
10	22	1	300	1.017706	40.0278	49.8612
11	22	3	300	0.93246	36.6749	66.6254
12	**18**	**3**	**300**	**0.854173**	**33.5958**	**82.021**
13	20	1	400	0.923848	36.3362	68.319
14	22	1	500	1.080254	42.4879	37.5607
15	20	3	400	0.928537	36.5206	67.3969
16	20	2	400	0.93806	36.8952	65.5241

Appendix A-3:

Table .4. The calculation of the adsorption capacity of CNAs/Al_2O_3 for Cr^{+3}

Sample Label	Ratio of Al %	Sonication Time	Calcination Temperature	Abs (50ppm=0.466)	Equilibrium Con(ppm)	Qe (mg/g) of 2-NP
1	20	2	500	0.311	33.3691	83.1545
2	18	1	500	0.313	33.5837	82.0815
3	18	1	300	0.32	34.3348	78.3262
4	18	2	400	0.293	31.4378	92.8112
5	20	2	300	0.312	33.4764	82.618
6	20	2	400	0.319	34.2275	78.8627
7	18	3	500	0.292	31.3305	93.3476
8	22	2	400	0.303	32.5107	87.4464
9	22	3	500	0.298	31.9742	90.1288
10	22	1	300	0.327	35.0858	74.5708
11	22	3	300	0.301	32.2961	88.5193
12	**18**	**3**	**300**	**0.286**	**30.6867**	**96.5665**
13	20	1	400	0.346	37.1245	64.3777
14	22	1	500	0.314	33.691	81.5451
15	20	3	400	0.319	34.2275	78.8627
16	20	2	400	0.321	34.4421	77.7897

Appendix A-4:

Table .5. The Batch adsorption experiments and their Response.

		Factor 1	**Factor 2**	**Factor 3**	**Response 1**	**Response 2**
Std	Run	A: Impregnation-Ratio(%)	B: Sonication Time hr	C: Calcination Temperature C	Adsorption Capacity (2-NPh) mg/g	Adsorption Capacity (Cr) mg/g
14	1	20	2	500	56.7795	83.1545
5	2	18	1	500	71.3215	82.0815
1	3	18	1	300	72.4228	78.3262
9	4	18	2	400	71.1316	92.8112
13	5	20	2	300	72.9265	82.618
15	6	20	2	400	65.2877	78.8627
7	7	18	3	500	60.9188	93.3476
10	8	22	2	400	45.2728	87.4464
8	9	22	3	500	38.2899	90.1288
2	10	22	1	300	49.8612	74.5708
4	11	22	3	300	66.6254	88.5193
3	12	18	3	300	82.021	96.5665
11	13	20	1	400	68.319	64.3777
6	14	22	1	500	37.5607	81.5451
12	15	20	3	400	67.3969	78.8627
16	16	20	2	400	65.5241	77.7897

Appendix B-1

Table. 8. Criteria of the Optimization the adsorption capacity of the 2-NPh and Cr^{3+}

Name	Goal	Lower Limit	Upper Limit	Lower Weight	Upper Weight	Importance
A: Impregnation-Ratio	is in range	18	22	1	1	3
B: Sonication Time	is in range	1	3	1	1	3
C: Calcination Temperature	is in range	300	500	1	1	3
Adsorption Capacity(2-NPh)	maximize	37.5607	82.021	1	1	5
Adsorption Capacity (Cr^{3+})	maximize	64.3777	96.5665	1	1	5

Appendix B-2

Table.9. Report the Optimization Findings for the Adsorption capacity of 2-NPh (*100 solutions)*

Number	Impregnation-Ratio	Sonication Time	Calcination Temperature	Adsorption Capacity (2NP)	Desirability
1	19.230	2.975	300.998	82.591	1.000
2	18.766	2.970	306.930	82.023	1.000
3	19.234	2.976	300.001	82.695	1.000
4	18.671	2.934	302.351	82.056	1.000
5	19.392	2.989	305.887	82.027	1.000
6	18.647	2.975	303.759	82.265	1.000
7	19.194	2.986	304.828	82.343	1.000
8	19.173	2.927	300.809	82.203	1.000
9	18.638	2.989	304.601	82.295	1.000
10	18.478	2.965	302.020	82.088	1.000
11	18.643	2.974	302.153	82.404	1.000
12	18.834	2.976	305.680	82.239	1.000
13	18.742	2.972	304.908	82.222	1.000
14	19.081	2.947	302.892	82.243	1.000
15	18.797	2.997	300.703	82.897	1.000
16	18.458	2.988	302.536	82.211	1.000
17	18.859	2.946	303.558	82.175	1.000
18	19.352	2.999	300.798	82.708	1.000
19	18.886	2.945	302.561	82.272	1.000
20	18.437	2.992	303.580	82.102	1.000
21	19.512	2.986	300.777	82.313	1.000
22	18.687	2.982	302.355	82.503	1.000
23	19.086	2.989	302.707	82.655	1.000
24	18.442	2.986	302.570	82.155	1.000
25	18.868	2.909	301.199	82.067	1.000

26	18.749	2.968	302.181	82.445	1.000	
27	19.086	2.978	307.525	82.063	1.000	
28	18.731	2.959	302.580	82.317	1.000	
29	19.022	2.955	300.407	82.581	1.000	
30	19.200	2.957	300.088	82.539	1.000	
31	18.672	2.998	308.509	82.042	1.000	
32	19.380	2.985	304.479	82.150	1.000	
33	18.947	2.969	303.405	82.425	1.000	
34	19.435	2.988	303.427	82.201	1.000	
35	18.748	2.986	308.290	82.025	1.000	
36	19.391	2.989	301.142	82.518	1.000	
37	18.316	2.992	300.200	82.156	1.000	
38	18.248	2.999	300.346	82.032	1.000	
39	19.003	2.926	302.885	82.075	1.000	
40	18.758	2.955	303.533	82.208	1.000	
41	18.466	2.984	300.622	82.364	1.000	
42	18.336	2.998	300.084	82.267	1.000	
43	19.031	2.957	305.062	82.140	1.000	
44	19.150	2.931	301.069	82.228	1.000	
45	19.065	2.973	301.770	82.599	1.000	
46	19.002	2.987	307.952	82.135	1.000	
47	18.887	2.997	306.445	82.371	1.000	
48	19.104	2.940	302.118	82.244	1.000	
49	18.603	2.958	304.135	82.022	1.000	
50	19.081	2.987	301.835	82.725	1.000	
51	18.332	2.975	300.315	82.030	1.000	
52	18.414	2.982	301.973	82.126	1.000	
53	**19.108**	**2.989**	**300.160**	**82.899**	**1.000**	**Selected**
54	18.701	2.981	307.446	82.021	1.000	
55	19.247	2.953	301.431	82.321	1.000	
56	18.377	2.995	301.191	82.233	1.000	
57	19.337	2.994	301.080	82.649	1.000	
58	18.700	2.962	300.859	82.477	1.000	
59	18.876	2.917	302.268	82.045	1.000	
60	18.988	2.937	303.645	82.104	1.000	
61	18.803	2.945	300.737	82.411	1.000	
62	19.365	2.990	305.930	82.071	1.000	
63	18.655	2.979	306.224	82.076	1.000	
64	18.580	2.995	300.142	82.701	1.000	
65	18.383	2.996	302.581	82.123	1.000	

66	18.911	2.972	307.161	82.080	1.000
67	18.700	2.970	304.232	82.228	1.000
68	18.771	2.953	301.309	82.414	1.000
69	19.060	2.933	303.165	82.089	1.000
70	18.826	2.942	301.256	82.350	1.000
71	19.322	2.972	302.420	82.317	1.000
72	18.523	2.910	300.001	81.873	0.997
73	19.171	2.878	300.000	81.823	0.996
74	18.198	3.000	302.745	81.684	0.992
75	18.761	3.000	313.425	81.652	0.992
76	18.106	2.999	300.000	81.647	0.992
77	18.000	2.998	301.632	81.130	0.980
78	18.242	2.847	300.000	80.763	0.972
79	18.000	2.848	300.000	80.056	0.956
80	18.000	3.000	315.489	79.915	0.953
81	19.139	3.000	337.742	79.096	0.934
82	18.362	2.176	300.000	76.600	0.878
83	19.101	1.955	300.000	75.391	0.851
84	18.516	1.733	300.002	74.912	0.840
85	18.521	1.504	300.001	74.318	0.827
86	18.423	1.502	300.000	74.300	0.826
87	18.310	1.509	300.002	74.254	0.825
88	18.355	1.000	300.003	73.936	0.818
89	18.355	1.000	300.005	73.936	0.818
90	18.383	1.000	300.036	73.935	0.818
91	18.360	1.033	300.015	73.922	0.818
92	18.377	1.044	300.001	73.918	0.818
93	18.420	1.154	300.004	73.916	0.818
94	18.392	1.058	300.002	73.914	0.818
95	18.212	1.000	323.499	73.853	0.816
96	18.669	1.000	318.278	73.630	0.811
97	18.000	1.000	377.468	73.475	0.808
98	18.027	1.000	387.084	73.398	0.806
99	19.188	1.166	300.022	72.807	0.793
100	18.000	1.000	497.860	71.577	0.765

Appendix B-3

Table.10. Report Oof the Optimization Findings for the Adsorption capacity of Cr^{3+} *(81 solutions*)

Number	Impregnation-Ratio	Sonication Time	Calcination Temperature	Adsorption Capacity (Cr)	Desirability	
1	18.003	2.389	499.835	96.569	1.000	
2	18.024	2.852	307.059	96.788	1.000	
3	18.000	3.000	300.000	96.916	1.000	
4	18.001	2.398	499.558	96.570	1.000	
5	18.002	2.417	499.894	96.574	1.000	
6	18.047	2.737	309.330	96.702	1.000	
7	**18.004**	**2.818**	**300.091**	**97.747**	**1.000**	**Selected**
8	18.057	2.693	305.696	96.948	1.000	
9	18.001	2.331	499.872	96.569	1.000	
10	18.059	2.736	308.587	96.610	1.000	
11	18.001	2.323	499.988	96.570	1.000	
12	18.022	2.843	305.691	96.961	1.000	
13	18.010	2.787	302.890	97.543	1.000	
14	18.001	2.354	499.730	96.572	1.000	
15	18.000	2.464	499.994	96.567	1.000	
16	18.040	2.866	302.421	96.910	1.000	
17	18.007	2.287	305.851	96.978	1.000	
18	18.066	2.543	305.330	96.948	1.000	
19	18.008	2.835	310.602	96.783	1.000	
20	18.003	2.364	499.983	96.568	1.000	
21	18.029	2.721	307.489	97.105	1.000	
22	18.086	2.539	305.053	96.717	1.000	
23	18.066	2.719	301.279	97.139	1.000	
24	18.015	2.192	302.917	96.578	1.000	
25	18.038	2.489	302.671	97.438	1.000	
26	18.004	2.983	304.557	96.577	1.000	
27	18.005	2.594	321.366	96.571	1.000	
28	18.001	2.428	499.775	96.569	1.000	
29	18.004	2.462	308.030	97.414	1.000	
30	18.033	2.879	303.587	96.841	1.000	
31	18.003	2.871	302.380	97.353	1.000	
32	18.012	2.266	300.383	97.220	1.000	
33	18.055	2.386	302.910	96.980	1.000	
34	18.029	2.565	313.501	96.809	1.000	

35	18.002	2.343	499.905	96.570	1.000
36	18.001	2.440	499.874	96.576	1.000
37	18.001	2.494	320.880	96.605	1.000
38	18.040	2.685	312.541	96.658	1.000
39	18.003	2.951	302.849	96.926	1.000
40	18.070	2.604	308.603	96.658	1.000
41	18.024	2.433	311.252	96.877	1.000
42	18.016	2.455	317.840	96.566	1.000
43	18.001	2.351	498.700	96.501	0.998
44	18.000	2.250	500.000	96.462	0.997
45	18.000	2.546	500.000	96.423	0.996
46	18.000	2.604	500.000	96.259	0.990
47	18.000	2.618	500.000	96.211	0.989
48	18.034	2.420	499.999	96.210	0.989
49	18.000	2.626	499.999	96.183	0.988
50	18.037	2.348	499.999	96.179	0.988
51	18.000	1.975	499.999	95.294	0.960
52	18.000	2.459	476.274	95.250	0.959
53	18.000	2.310	345.258	94.852	0.947
54	18.000	1.905	300.000	94.594	0.939
55	18.000	2.516	372.726	94.231	0.927
56	18.000	2.553	382.795	93.970	0.919
57	22.000	2.276	500.000	93.858	0.916
58	22.000	2.283	500.000	93.855	0.916
59	22.000	2.249	500.000	93.852	0.916
60	22.000	2.358	500.000	93.807	0.914
61	18.000	2.542	393.045	93.798	0.914
62	18.000	2.475	423.941	93.760	0.913
63	18.000	2.448	423.180	93.750	0.913
64	22.000	2.272	498.502	93.728	0.912
65	21.987	2.260	500.000	93.727	0.912
66	18.000	2.574	396.265	93.726	0.912
67	18.000	2.456	417.510	93.712	0.911
68	21.983	2.273	500.000	93.689	0.911
69	21.964	2.253	499.999	93.488	0.904
70	21.957	2.241	500.000	93.417	0.902
71	22.000	2.208	491.145	93.069	0.891
72	22.000	2.477	300.000	91.076	0.829
73	21.996	2.508	300.001	91.034	0.828
74	21.992	2.435	300.000	90.992	0.827

75	22.000	2.490	304.323	90.824	0.822
76	22.000	2.462	313.648	90.334	0.806
77	22.000	2.361	314.226	90.226	0.803
78	21.999	2.071	300.000	89.807	0.790
79	22.000	2.029	310.160	89.038	0.766
80	22.000	2.420	407.832	88.912	0.762
81	22.000	2.386	382.451	88.669	0.755