CALCULATION DATA

1. Synthesis HZSM-5

Ratio molar: 10Na_2O: 50SiO_2: 1Al_2O_3: 20TPABr: 1800H_2O

0.0192Na_2O: 0.0962SiO_2: 0.0019Al_2O_3: 0.0385TPABr: 3.4615H_2O

- Na_2O supplied from NaOH

$Na_2O + H_2O \rightarrow 2NaOH$

n Na_2O = 0.0192 mole ; n NaOH = 0.0384 mole

mass = n x BM = 0.0384 x 40 = 1.536 grams

- SiO_2 supplied from Ludox (30%wt SiO_2)

mass SiO_2 = n x BM = 0.0962 x 60 = 5.772 grams

$$mass\ ludox = \frac{5.772}{0.3} = 19.24\ grams$$

- Al_2O_3 supplied from Aluminium isopropoxide ($Al(OCH(CH_3)_2)_3$)

$2Al(OCH(CH_3)_2)_3 + H_2O \rightarrow Al_2O_3 + 6C_3H_7OH$

n Al_2O_3 = 0.0019 mole ; n $Al(OCH(CH_3)_2)_3$ = 0.0038 mole

mass = n x BM = 0.0038 x 204 = 0.7752 grams

- TPABr ($C_{12}H_{28}NBr$)

mass = n x BM = 0.0385 x 266 = 10.241 grams

- Distilled Water (H_2O)

mass total = n x BM = 3.4615 x 18 = 62.307 grams

2. Ion-Exchange with NH_4NO_3 1 M Solution

$$mass = \frac{M \times BM \times V}{1000} = \frac{1 \times 80 \times 200}{1000} = 16\ grams$$

3. Impregnation Ni-Zr into Support HZSM-5

$$Total\ metal\ mass = loading\ logam \times total\ catalyst\ mass$$
$$= 5\% \times 5\ gram$$
$$= 0.25\ gram$$
$$Mass\ \text{HZSM} - 5 = total\ catalyst\ mass - total\ metal\ mass$$
$$= 5\ gram - 0.25\ gram$$
$$= 4.75\ gram$$

- 5% (1:1)

$$Masss\ Ni = \frac{ratio\ Ni}{ratio\ total} \times total\ metal\ mass$$
$$= \frac{1}{2} \times 0.25$$
$$= 0.125\ grams$$

$$Massa\ logam\ Zr = \frac{ratio\ Zr}{ratio\ total} \times total\ metal\ mass$$
$$= \frac{1}{2} \times 0.25$$
$$= 0.125\ grams$$

$$Massa\ Ni(NO_3)_2.6H_2O = \frac{BM\ precursor}{Ar\ Ni} \times \%\ purity \times mass\ Ni$$
$$= \frac{290.69\ g/mol}{58.69\ g/mol} \times \frac{1}{0.98} \times 0.125$$
$$= 0.6318\ grams$$

$$Massa\ ZrO(NO_3)_2.H_2O = \frac{BM\ precursor}{Ar\ Zr} \times \%\ purity \times mass\ Zr$$
$$= \frac{249.22\ g/mol}{91.22\ g/mol} \times \frac{1}{0.98} \times 0.125$$
$$= 0.3485\ grams$$

- 5% (1:2)

$$Masss\ Ni = \frac{ratio\ Ni}{ratio\ total} \times total\ metal\ mass$$
$$= \frac{1}{3} \times 0.25$$
$$= 0.0833\ grams$$

$$Massa\ logam\ Zr = \frac{ratio\ Zr}{ratio\ total} \times total\ metal\ mass$$
$$= \frac{2}{3} \times 0.25$$
$$= 0.1666\ grams$$

$$Massa\ Ni(NO_3)_2.6H_2O = \frac{BM\ precursor}{Ar\ Ni} \times \%\ purity \times mass\ Ni$$
$$= \frac{290.69\ g/mol}{58.69\ g/mol} \times \frac{1}{0.98} \times 0.0833$$
$$= 0.4210\ grams$$

$$Massa\ ZrO(NO_3)_2.H_2O = \frac{BM\ precursor}{Ar\ Zr} \times \%\ purity \times mass\ Zr$$
$$= \frac{249.22\ g/mol}{91.22\ g/mol} \times \frac{1}{0.98} \times 0.1666$$
$$= 0.4645\ grams$$

- 5% (2:1)

$$Masss\ Ni = \frac{ratio\ Ni}{ratio\ total} \times total\ metal\ mass$$
$$= \frac{2}{3} \times 0.25$$
$$= 0.1666\ grams$$

$$Massa\ logam\ Zr = \frac{ratio\ Zr}{ratio\ total} \times total\ metal\ mass$$
$$= \frac{1}{3} \times 0.25$$
$$= 0.0833\ grams$$

$$Massa\ Ni(NO_3)_2.6H_2O = \frac{BM\ precursor}{Ar\ Ni} \times \%\ purity \times mass\ Ni$$
$$= \frac{290.69\ g/mol}{58.69\ g/mol} \times \frac{1}{0.98} \times 0.1666$$
$$= 0.8420\ grams$$

$$Massa\ ZrO(NO_3)_2.H_2O = \frac{BM\ precursor}{Ar\ Zr} \times \%\ purity \times mass\ Zr$$
$$= \frac{249.22\ g/mol}{91.22\ g/mol} \times \frac{1}{0.98} \times 0.0833$$
$$= 0.2322\ grams$$

4. Transesterification Sunflower Seed Oil

Reaction conditions: 3wt% catalyst ; rasio oil:methanol (1:15) ; 60^{o}C ; 3 and 5 h

mass sunflower seed oil = 40 grams

mass catalyst = 3% x 40 grams = 1.2 grams

ρ oil = 0.92 g/mL

$V\ oil = \frac{mass}{\rho} = \frac{40}{0.92} = 43.4783\ mL$; $n\ oil = \frac{40}{876} = 0.0456\ mole$

n methanol = 0.0456 x 15 = 0.6849 mole

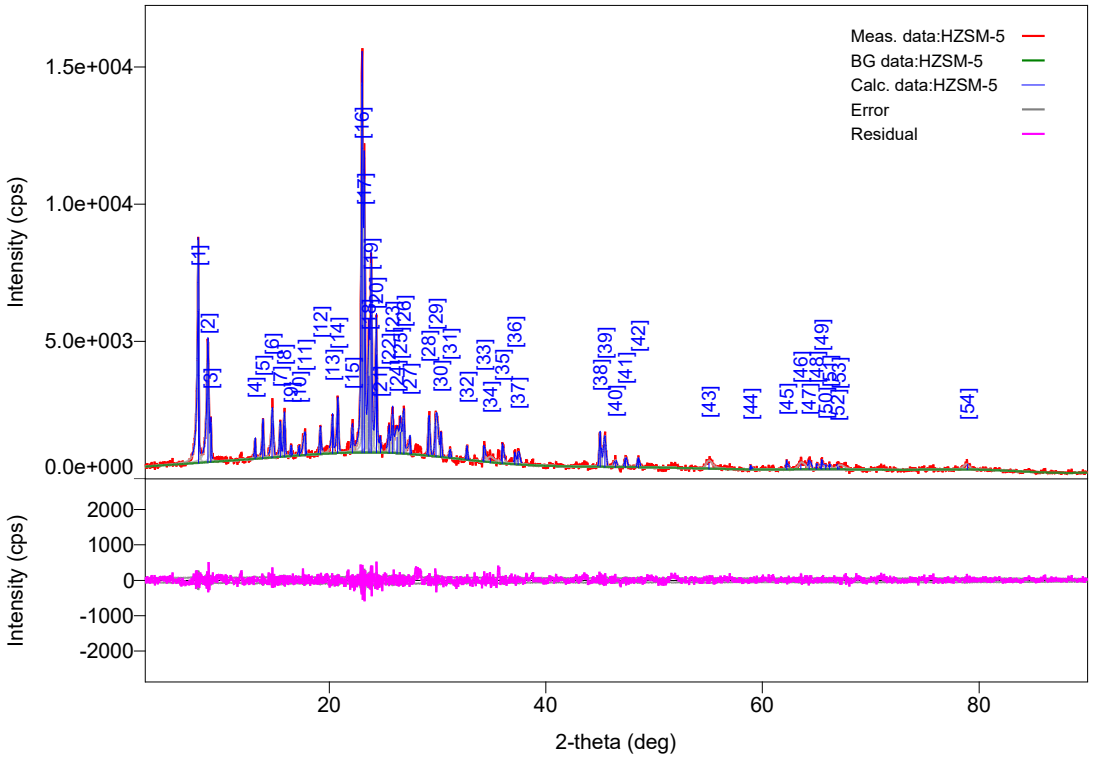
mass methanol = n x BM = 0.6849 x 32 = 21.9178 grams

ρ oil = 0.79 g/mL

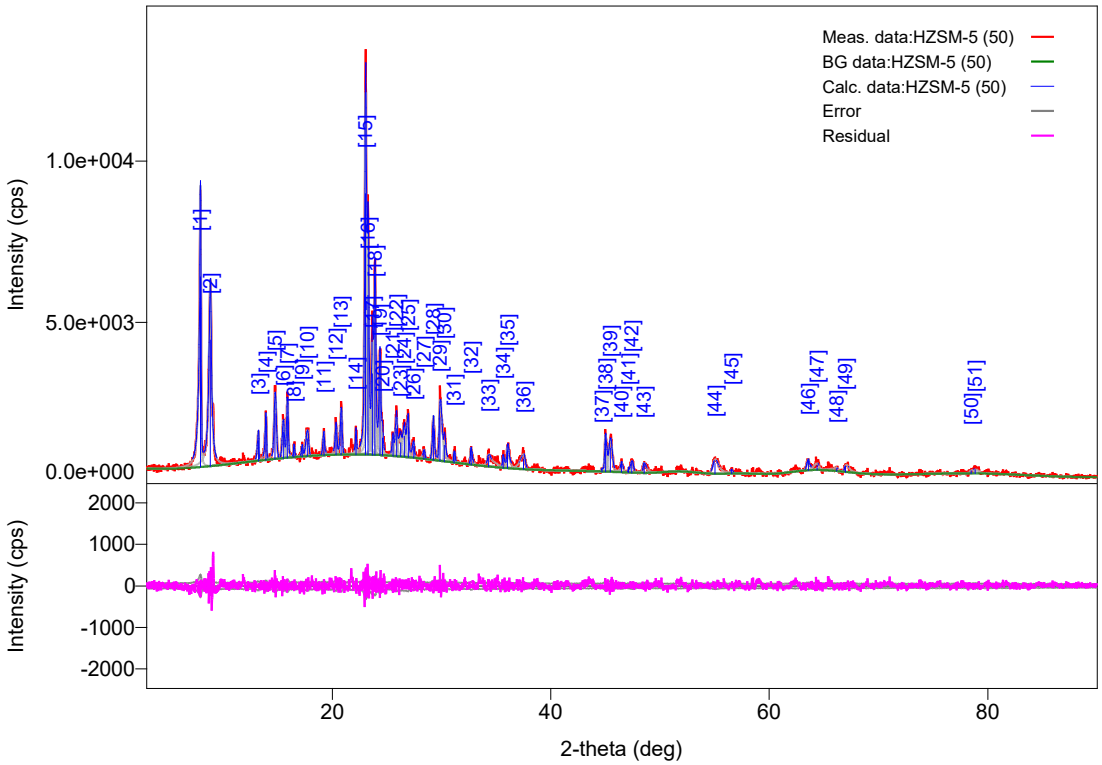
$$V\ methanol = \frac{mass}{\rho} = \frac{21.9178}{0.79} = 27.7441\ mL$$

X-Ray Diffraction (XRD)

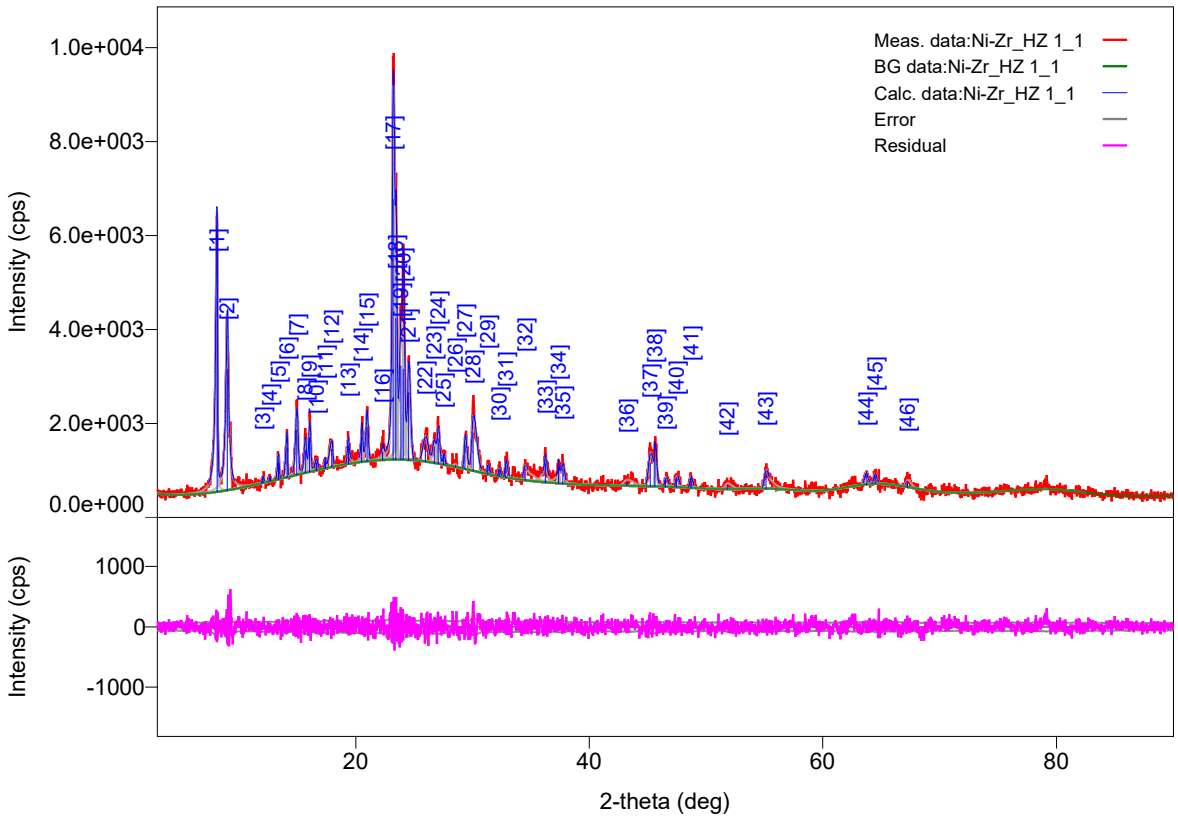
- HZSM-5 (C)



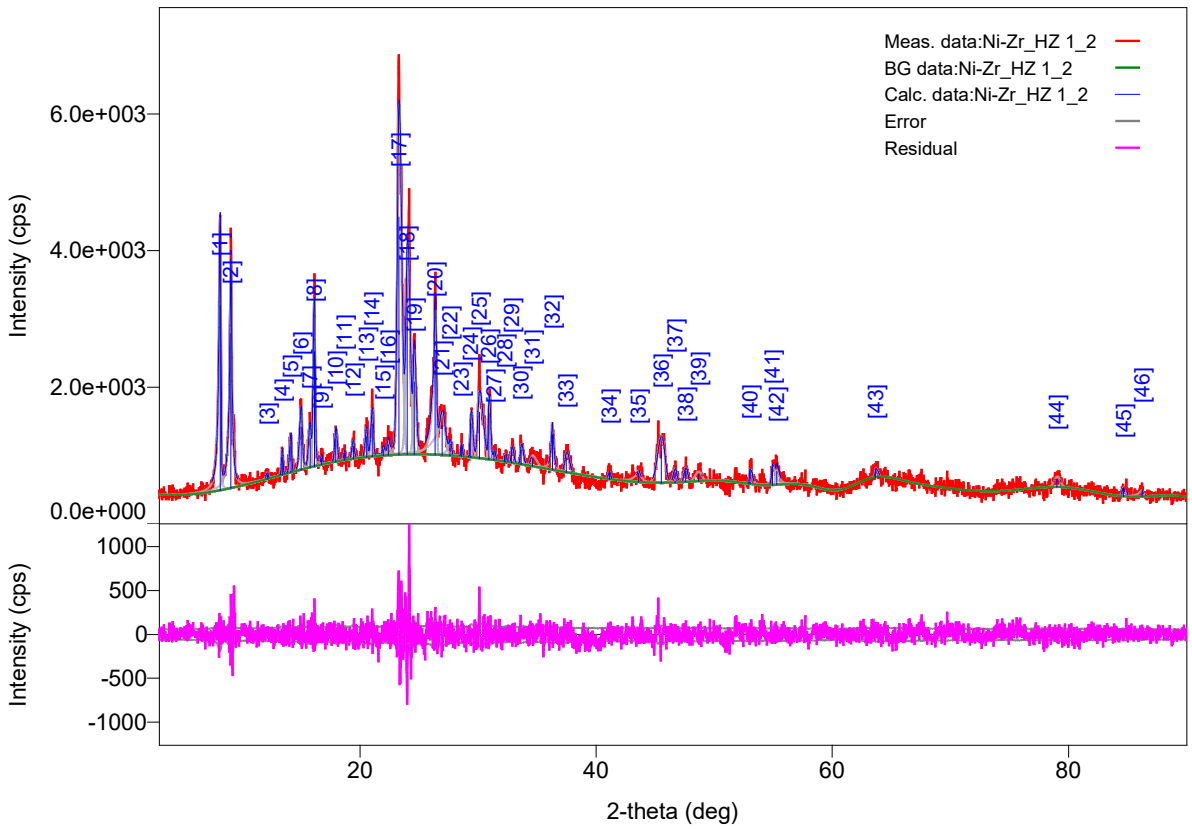
- HZSM-5 (S)



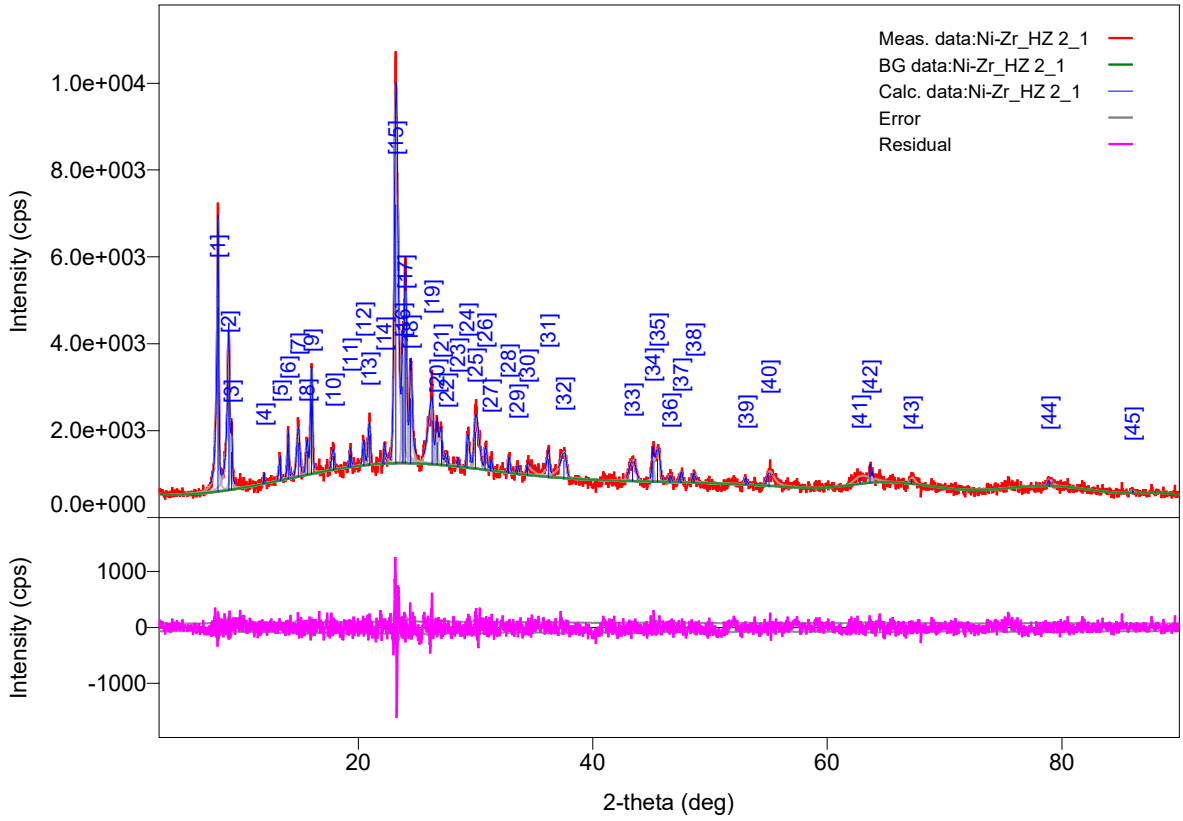
- Ni-Zr/HZ (1:1)



- Ni-Zr/HZ (1:2)



- Ni-Zr/HZ (2:1)



Crystallinity

HZSM-5 (C)		HZSM-5 (S)		Ni-Zr/HZ (1:1)		Ni-Zr/HZ (1:2)		Ni-Zr/HZ (2:1)	
Area	Total Peak Area	Area	Total Peak Area	Area	Total Peak Area	Area	Total Peak Area	Area	Total Peak Area
3455.75	53311.83	3820.17	50574.42	2281.83	49256.08	1404.08	45962.67	1965.33	52725
2676.67		3137.58		1995.75		1998.17		2216.67	
532.00		849.75		1456.25		1046.92		1126.17	
368.42		905.17		546.92		419.33		629.50	
483.50		689.00		1021.33		886.42		750.00	
1049.33		1231.00		514.42		1329.25		1372.50	
1062.83		620.42		631.83		370.33		584.08	
172.92		733.92		504.50		1015.33		1271.33	
1168.83		653.25		1266.83		275.33		698.17	
414.75		335.00		1343.33		762.17		1041.50	
478.17		1099.08		940.17		737.08		911.42	

930.58	954.83	945.50	754.50	885.50
1109.08	981.75	1208.50	895.67	4620.75
1186.92	745.00	4319.00	3207.75	2325.50
1126.50	693.25	2291.58	1850.67	1564.75
1052.92	558.42	1571.33	1528.50	1931.75
5748.17	4978.83	1045.50	1816.92	637.83
2978.75	2729.08	1394.17	989.83	471.50
1792.17	1494.08	560.75	492.83	672.83
890.08	744.00	640.25	688.33	872.83
630.08	691.00	752.08	773.33	684.67
709.42	891.50	1608.00	1115.75	1316.08
1192.75	735.75	518.58	1184.50	489.67
587.08	504.25	457.42	815.17	351.25
935.17	788.83	433.00	1535.25	1164.33
840.25	668.08	471.42	922.00	470.83
1423.33	1727.50	875.25	814.33	493.92
758.83	752.42	757.92	669.42	1310.50
873.25	526.08	322.92	734.50	2150.42
435.00	410.58	1226.42	473.67	802.42
454.08	587.92	510.17	577.67	1369.08
437.08	205.67	1164.00	77.83	123.00
243.92	225.42	270.42	910.17	1027.00
422.17	537.50	990.08	316.42	397.00
483.42	860.50	280.75	393.33	479.92
373.58	492.67	380.83	1179.50	762.17
385.17	1323.50	488.08	416.92	1606.75
1013.75	1022.00	407.92	413.42	868.00
685.25	267.83	1065.17	298.33	517.25
262.25	370.92	1985.33	823.83	574.17
961.67	723.42	854.25	463.17	2902.67
323.42	465.92	715.17	625.42	538.75

441.50	1182.00	745.42	723.50	1044.75
307.92	178.33	588.08	2100.92	1097.17
542.00	98.83	933.50	941.67	2080.25
650.75	404.75	2098.58	816.50	
1372.58	375.92			
323.25	407.75			
504.42	576.58			
262.17	468.83			
640.08	666.00			
440.92				
235.75				
786.00				

Crystal Size

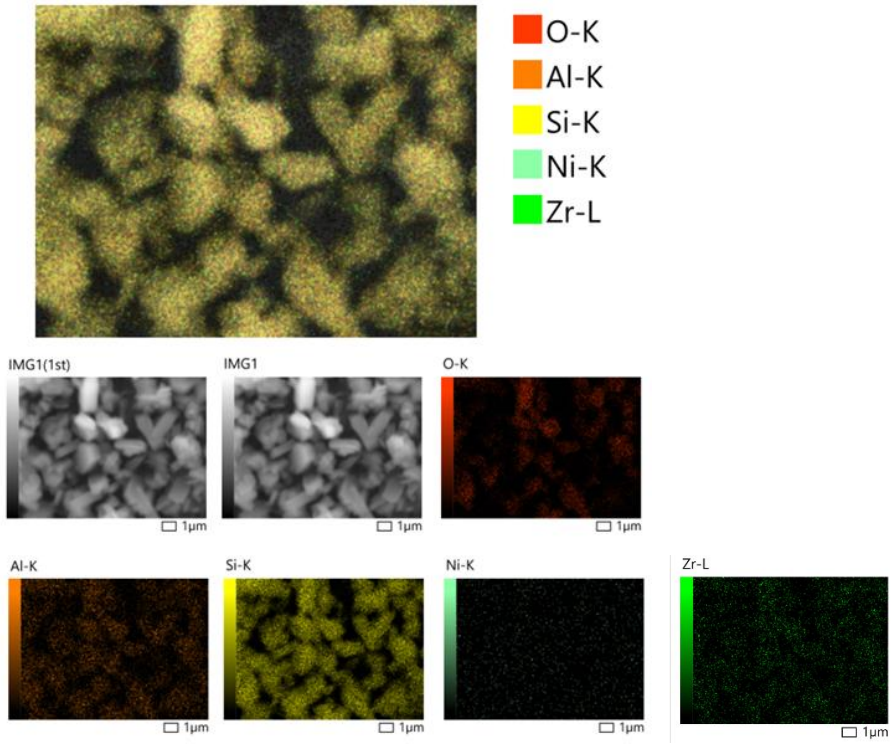
HZSM-5 (C)		HZSM-5 (S)		Ni-Zr/HZ (1:1)		Ni-Zr/HZ (1:2)		Ni-Zr/HZ (2:1)	
2theta	**FWHM**	**2theta**	**FWHM**	**2theta**	**FWHM**	**2theta**	**FWHM**	**2theta**	**FWHM**
7.9254	0.1386	7.9343	0.1595	8.1295	0.1876	8.1675	0.1977	8.0284	0.1686
8.8027	0.2059	8.8496	0.2551	9.0129	0.2631	9.0698	0.2152	8.9599	0.2201
9.0695	0.1102	13.2574	0.1511	12.0770	0.1560	12.1730	0.2090	9.2107	0.1330
13.1545	0.0871	13.9181	0.1441	12.6520	0.1170	13.4230	0.1420	11.9630	0.0540
13.8674	0.1289	14.7643	0.2379	13.3920	0.1732	14.1720	0.2052	13.3620	0.1632
14.7214	0.1871	15.5271	0.2151	14.1342	0.1841	15.0211	0.2802	14.0162	0.1391
15.4829	0.1461	15.9028	0.1748	14.9611	0.2591	15.7711	0.2530	14.8946	0.2981
15.8639	0.1661	16.4768	0.1220	15.6811	0.2222	16.1397	0.2017	15.6407	0.2352
16.4740	0.1130	17.2551	0.1530	16.0659	0.2111	16.7520	0.1470	16.0184	0.1966
17.2519	0.1320	17.7320	0.2922	16.6420	0.2750	17.9630	0.2520	17.8740	0.2740
17.7725	0.2692	19.2420	0.1630	17.4142	0.1040	18.7020	0.1280	19.3450	0.1740
19.2020	0.1530	20.3351	0.1652	17.9659	0.3430	19.4350	0.2440	20.4642	0.2130
20.3232	0.1520	20.8111	0.1881	19.3651	0.1830	20.5720	0.2130	20.9420	0.2332
20.7716	0.1407	22.1587	0.0772	20.5221	0.1620	21.0520	0.2520	22.2120	0.1870
22.1330	0.1520	23.0494	0.1617	20.9602	0.2292	21.9710	0.1916	23.2173	0.3567
23.0423	0.1485	23.2684	0.1802	22.3130	0.1810	22.4050	0.2210	23.7931	0.2130
23.2453	0.1429	23.6765	0.1701	23.2065	0.2471	23.2951	0.4201	24.0156	0.1792
23.6635	0.1609	23.9075	0.1701	23.4485	0.1401	24.0159	0.4122	24.4785	0.2332
23.8834	0.1548	24.3646	0.1831	23.8741	0.4320	24.5929	0.2720	26.3009	0.4820
24.3534	0.1485	24.5899	0.1240	24.0807	0.1382	26.3671	0.2330	26.7341	0.2650
24.7191	0.1030	25.5729	0.1452	24.5308	0.2882	26.9550	0.6590	27.0841	0.3680
25.5361	0.1720	25.8938	0.1852	25.9850	0.5250	27.6440	0.2515	27.5720	0.2880
25.8648	0.1602	26.2482	0.3370	26.7230	0.3470	28.5782	0.1460	28.4930	0.1790

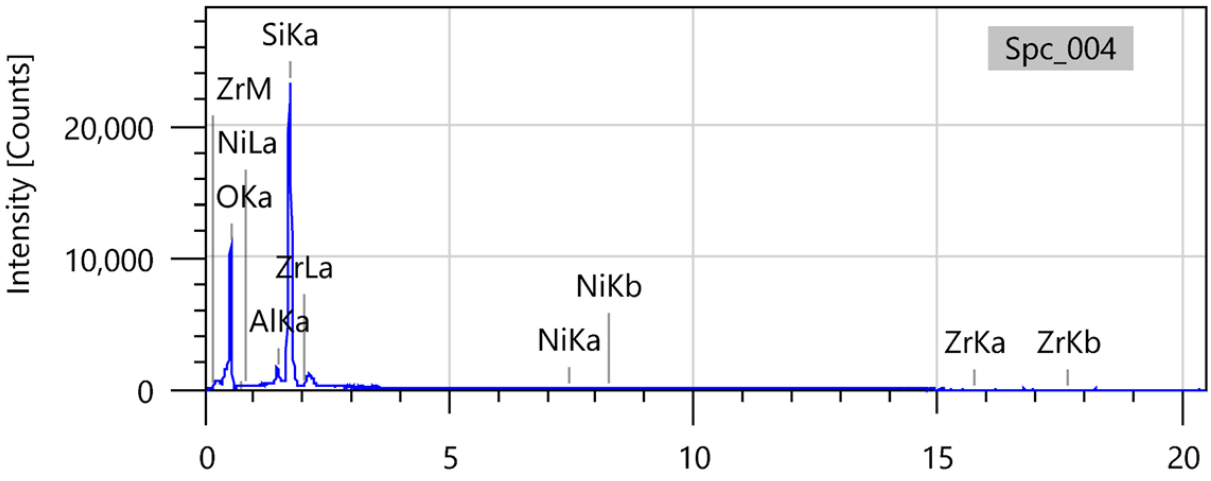
26.2720	0.4050	26.6081	0.2630	27.0772	0.2440	29.3987	0.2420	29.2957	0.2630
26.5718	0.1840	26.9541	0.2320	27.5430	0.2070	30.1078	0.5320	29.9926	0.4720
26.8921	0.2320	27.4531	0.2030	28.6300	0.3300	30.9206	0.2092	30.8171	0.2230
27.4631	0.1330	28.3850	0.1670	29.3498	0.2630	31.3530	0.1890	31.2822	0.1860
29.1784	0.1731	29.2707	0.1681	30.0577	0.4920	32.2930	0.1480	32.8281	0.1840
29.8595	0.3411	29.8563	0.2991	31.3062	0.2060	32.8552	0.2350	33.5410	0.2280
30.2905	0.1192	30.2507	0.1430	32.2750	0.1780	33.6442	0.2750	34.4570	0.3490
31.1470	0.1550	31.1462	0.1020	32.8550	0.2240	34.6040	0.5811	36.2220	0.2740
32.7130	0.1330	32.7051	0.1262	34.5220	0.5090	36.3012	0.1940	37.5540	0.5950
34.2841	0.1020	34.3120	0.4290	36.2520	0.2260	37.4920	0.4270	43.3960	0.6450
34.8980	0.8200	35.6371	0.1340	37.3756	0.0520	41.1350	0.1814	45.1091	0.1320
35.9891	0.1220	36.0541	0.2030	37.7440	0.3760	43.5940	0.3311	45.5330	0.5450
37.1268	0.0920	37.5250	0.5150	43.2250	0.9715	45.5240	0.7030	46.6030	0.2180
37.4471	0.2340	44.6930	0.1260	45.2081	0.5740	46.6730	0.3280	47.5220	0.2270
45.0097	0.1349	45.0139	0.1582	45.6297	0.1412	47.5930	0.3270	48.6330	0.2170
45.4492	0.2720	45.4720	0.3430	46.5220	0.2760	48.6760	0.6312	53.0620	0.1770
46.4282	0.2760	46.4852	0.1530	47.4682	0.2950	53.0272	0.1860	55.0380	0.6680
47.3550	0.2340	47.1311	0.0920	48.7220	0.2060	54.9430	0.2370	62.7910	1.7816
48.5330	0.1730	47.4140	0.2330	51.7950	0.6513	55.2930	0.2190	63.6559	0.0992
55.0580	0.6480	48.5312	0.2040	55.1250	0.4370	63.6940	0.1810	67.1640	0.4113
58.9140	0.0930	55.0250	0.5460	63.7250	0.2770	79.0118	0.5313	78.9050	0.2570
62.2441	0.1120	56.5550	0.1350	64.4950	0.2570	84.6660	0.2050	86.0390	0.2010
63.5320	0.7290	63.5830	0.2440	67.2340	0.4712	86.2240	0.3200		
64.2931	0.2030	64.3960	0.5211						
65.0151	0.1530	66.1740	0.4412						
65.4778	0.1362	66.9850	0.3360						
65.8352	0.1540	78.4770	0.5200						
66.1951	0.1530	78.8330	0.2710						
66.9430	0.1560								
67.0840	0.8190								
78.9030	0.4980								

Scanning Electron Microscope-Energi Dispersive X-Ray (SEM-EDX)

SEM-EDX

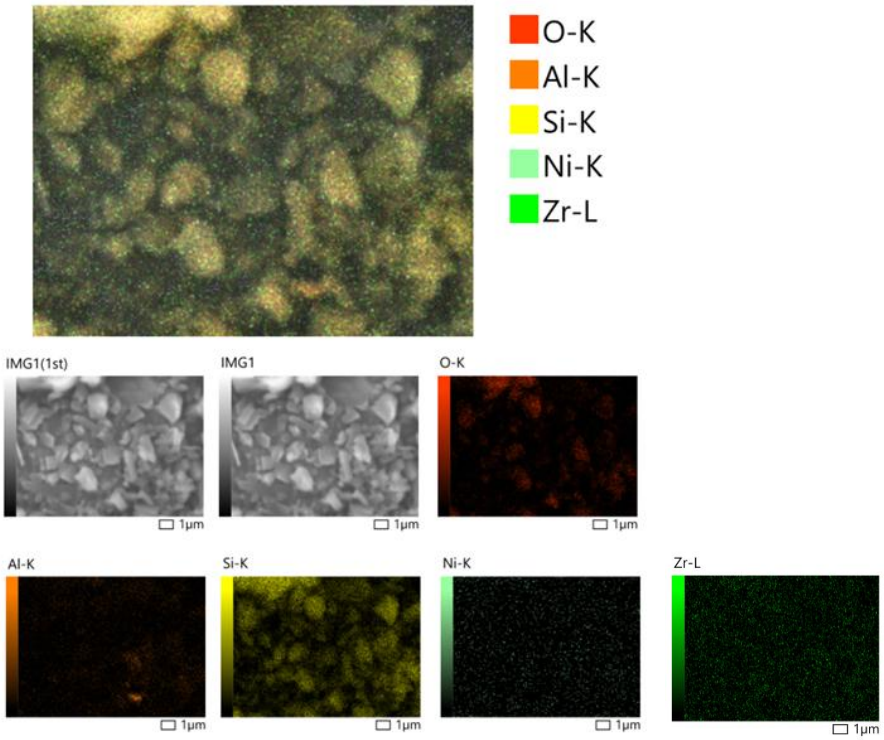
- HZSM-5 (C)

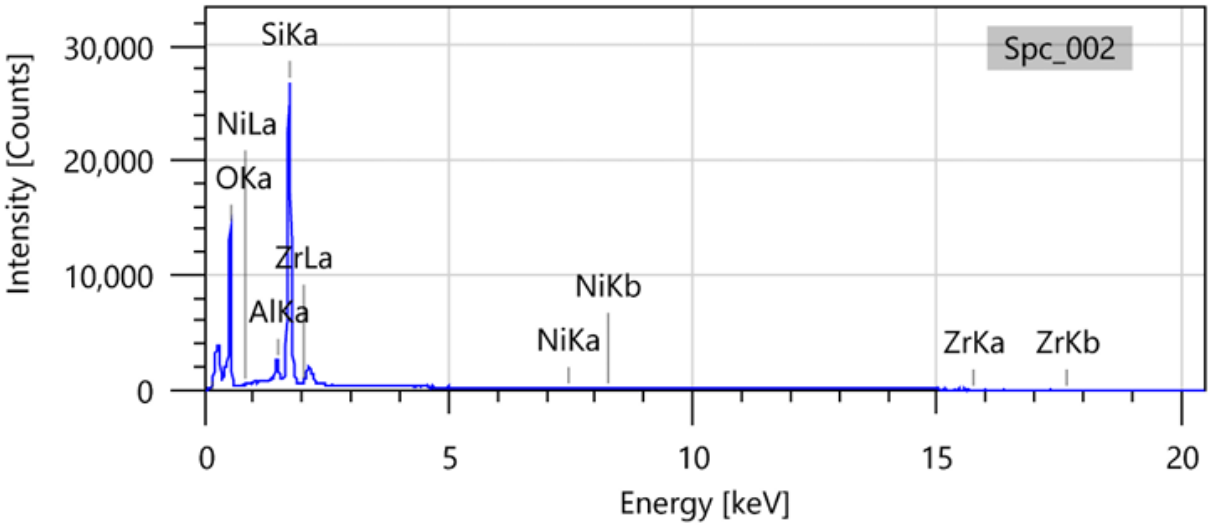




Element	Line	Mass%	Atom%
O	K	45.58±0.55	59.50±0.71
Al	K	2.55±0.09	1.97±0.07
Si	K	51.77±0.40	38.49±0.30
Ni	K	0.10±0.08	0.04±0.03
Zr	L	nd	nd
Total		100.00	100.00
Spc_004			Fitting ratio 0.0616

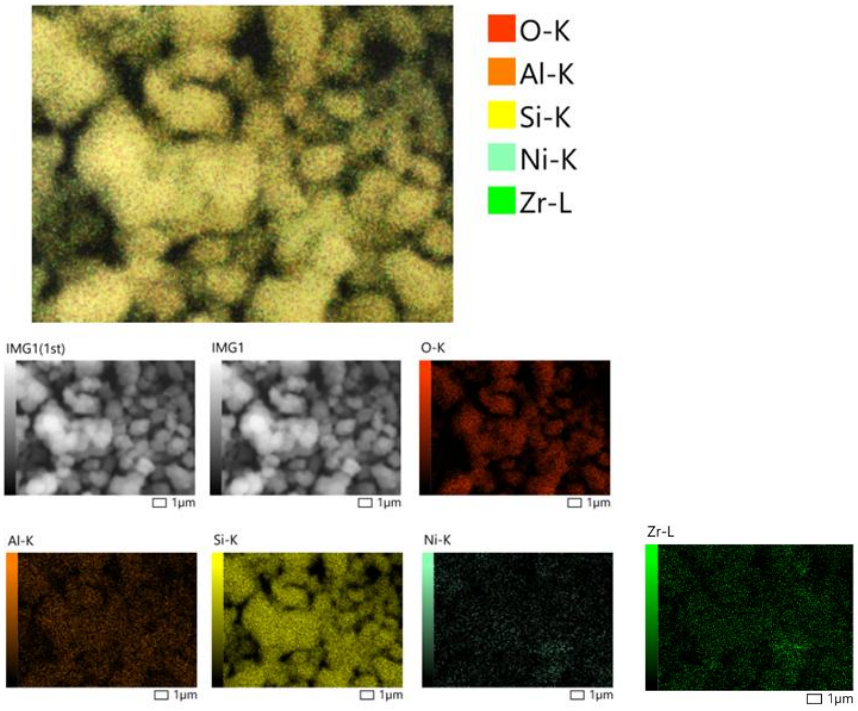
- HZSM-5 (S)

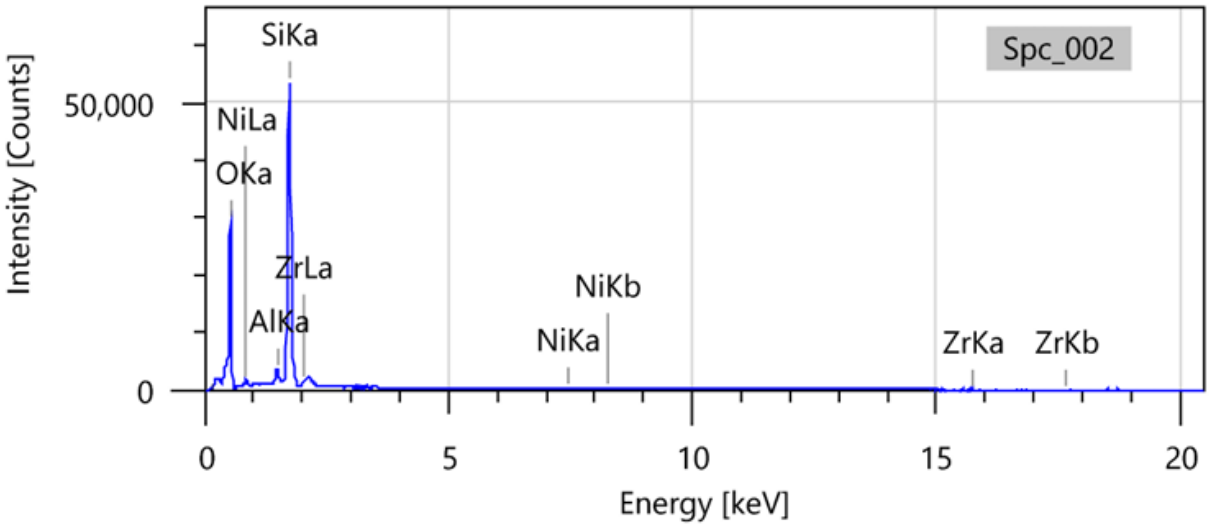




Element	Line	Mass%	Atom%
O	K	47.32±0.50	61.13±0.65
Al	K	3.33±0.10	2.55±0.07
Si	K	49.35±0.36	36.32±0.26
Ni	K	nd	nd
Zr	L	nd	nd
Total		100.00	100.00
Spc_002			Fitting ratio 0.1073

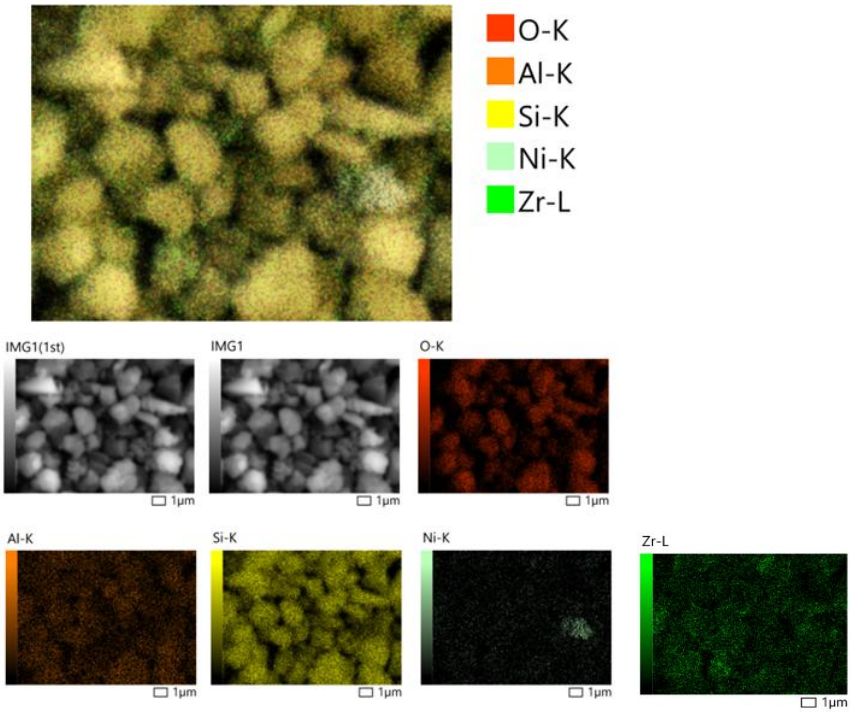
- Ni-Zr/HZ (1:1)

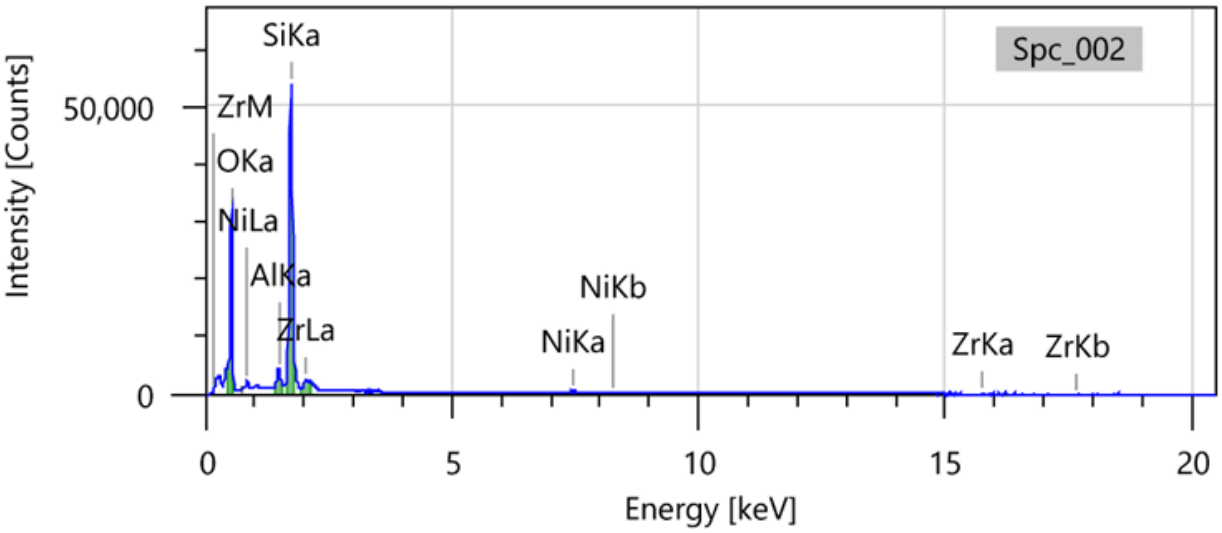




Element	Line	Mass%	Atom%
O	K	45.97±0.34	60.85±0.45
Al	K	2.22±0.05	1.74±0.04
Si	K	47.79±0.24	36.04±0.18
Ni	K	3.34±0.19	1.21±0.07
Zr	L	0.68±0.08	0.16±0.02
Total		100.00	100.00
Spc_002			Fitting ratio 0.0513

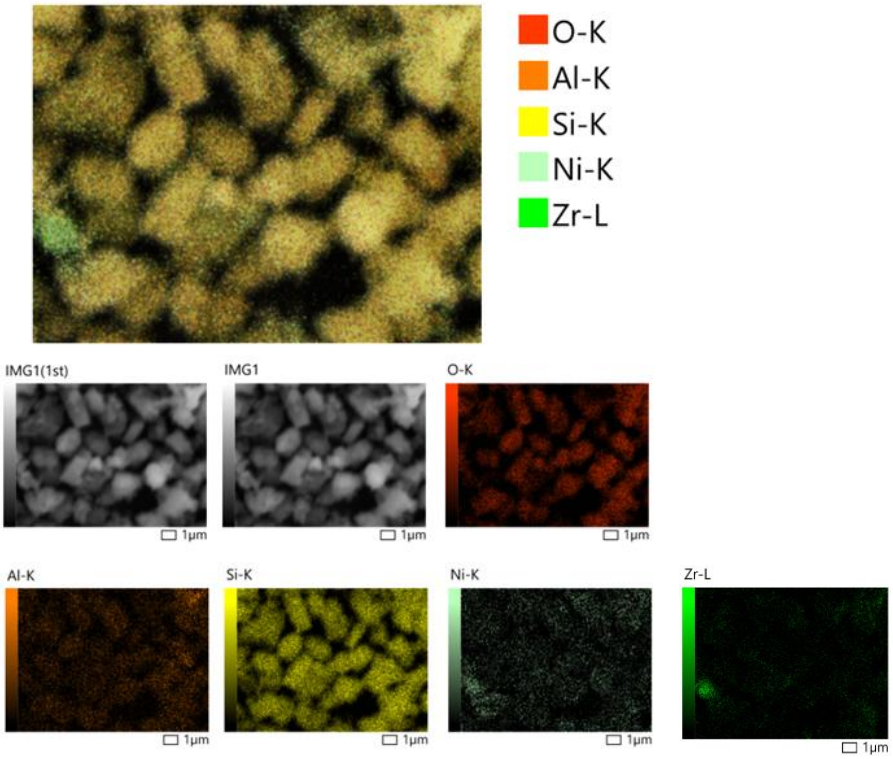
- Ni-Zr/HZ (1:2)

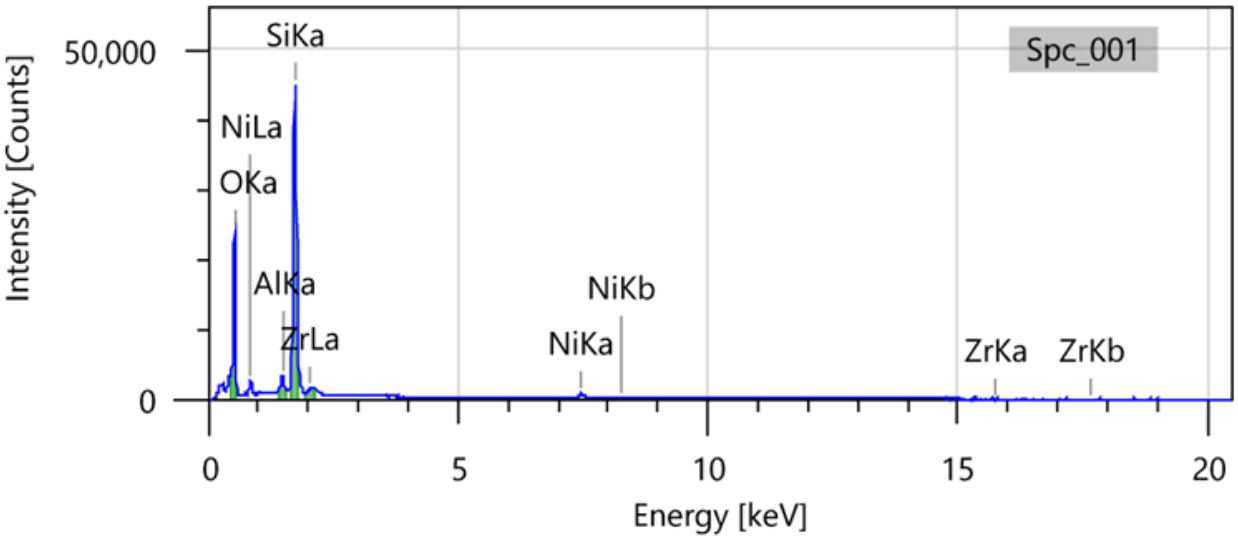




Element	Line	Mass%	Atom%
O	K	45.94±0.32	62.41±0.44
Al	K	2.51±0.05	2.02±0.04
Si	K	42.47±0.21	32.87±0.17
Ni	K	4.09±0.19	1.51±0.07
Zr	L	5.00±0.13	1.19±0.03
Total		100.00	100.00
Spc_002			Fitting ratio 0.0540

- Ni-Zr/HZ (2:1)





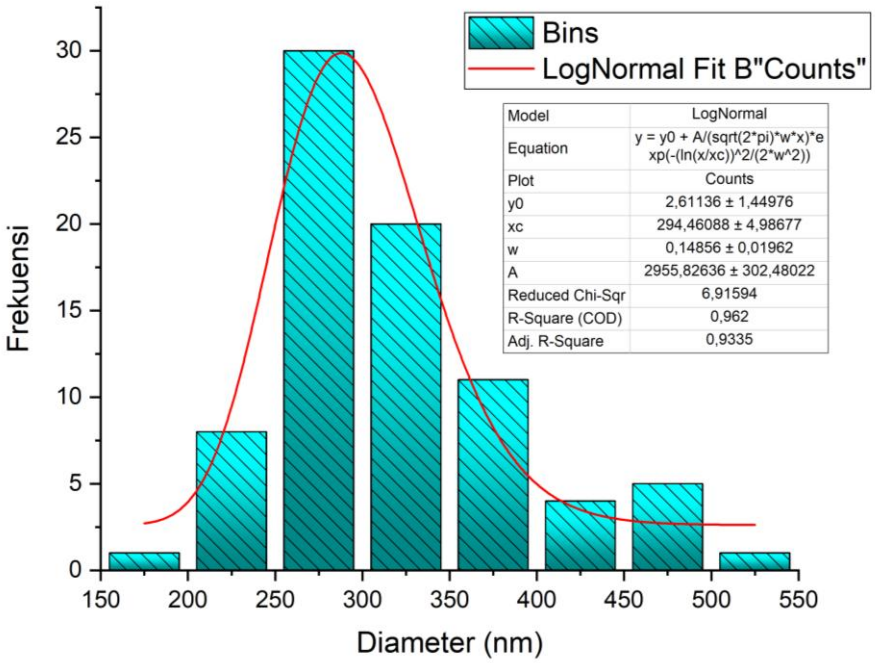
Element	Line	Mass%	Atom%
O	K	47.32±0.34	64.20±0.46
Al	K	2.44±0.06	1.96±0.05
Si	K	39.11±0.22	30.23±0.17
Ni	K	7.33±0.27	2.71±0.10
Zr	L	3.80±0.12	0.90±0.03
Total		100.00	100.00
Spc_003			Fitting ratio 0.0749

Particle Size

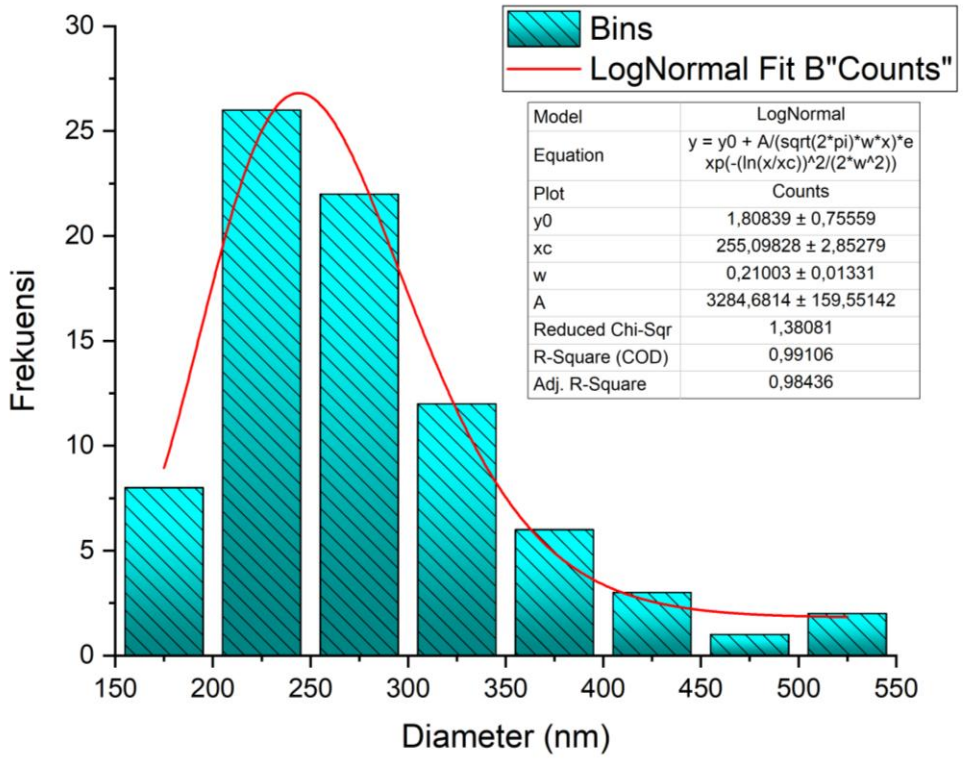
HZSM-5 (C)		HZSM-5 (S)		Ni-Zr/HZ (1:1)		Ni-Zr/HZ (1:2)		Ni-Zr/HZ (2:1)	
r	D (nm)	r	D (nm)	r	D (nm)	r	D (nm)	r	D (nm)
0.1802	360.3754	0.2056	411.2009	0.1409	281.8690	0.2153	430.5620	0.1427	285.4599
0.1424	284.8794	0.1888	377.6279	0.1612	322.3296	0.0930	186.0971	0.2268	453.6028
0.1442	288.4328	0.0903	180.5407	0.1354	270.8110	0.1596	319.1538	0.1497	299.3928
0.2125	424.9063	0.1009	201.8506	0.2056	411.2009	0.1427	285.4599	0.1719	343.7392
0.1560	312.0739	0.1612	322.3296	0.1847	369.4473	0.0903	180.5407	0.2925	585.0186
0.1148	229.6744	0.1173	234.5292	0.0984	196.7396	0.1612	322.3296	0.2916	583.2749
0.1963	392.6695	0.1928	385.6350	0.1704	340.7630	0.1409	281.8690	0.2864	572.7011
0.1560	312.0739	0.1257	251.3020	0.1296	259.2818	0.1335	267.0232	0.1194	238.8329
0.1442	288.4328	0.1445	289.0061	0.1915	382.9846	0.1531	306.1216	0.0984	196.7396
0.2002	400.3759	0.1128	225.6758	0.1580	315.9462	0.1082	216.4607	0.1373	274.5465
0.1911	382.1526	0.1689	337.7607	0.1580	315.9462	0.1082	216.4607	0.1354	270.8110
0.1080	216.0190	0.0814	162.7372	0.1445	289.0061	0.1733	346.6898	0.1612	322.3296
0.1407	281.3038	0.1354	270.8110	0.1531	306.1216	0.0957	191.4923	0.0957	191.4923
0.1830	365.9847	0.1277	255.3231	0.1128	225.6758	0.2056	411.2009	0.1106	221.1163
0.0956	191.1262	0.1296	259.2818	0.1106	221.1163	0.1643	328.5890	0.1391	278.2319
0.1511	302.1655	0.2044	408.7163	0.1215	243.0603	0.1980	396.0595	0.2105	420.9928
0.1442	288.4328	0.0957	191.4923	0.1296	259.2818	0.0957	191.4923	0.1427	285.4599
0.1388	277.6822	0.1354	270.8110	0.1296	259.2818	0.1733	346.6898	0.1106	221.1163
0.2100	420.0845	0.1009	201.8506	0.1082	216.4607	0.1034	206.8353	0.1980	396.0595
0.1274	254.8239	0.1151	230.1451	0.1236	247.2155	0.1009	201.8506	0.1194	238.8329
0.1528	305.5179	0.1719	343.7392	0.1427	285.4599	0.1354	270.8110	0.1391	278.2319
0.2415	483.0992	0.1059	211.7027	0.1128	225.6758	0.1564	312.7056	0.1791	358.2493
0.1234	246.7257	0.1497	299.3928	0.1215	243.0603	0.1847	369.4473	0.1373	274.5465
0.1730	345.9913	0.0957	191.4923	0.1034	206.8353	0.1296	259.2818	0.1531	306.1216
0.2089	417.8051	0.1819	363.8913	0.1215	243.0603	0.1151	230.1451	0.1480	295.9711
0.1858	371.5093	0.1151	230.1451	0.1034	206.8353	0.1763	352.5169	0.0903	180.5407
0.1608	321.6771	0.1733	346.6898	0.1194	238.8329	0.1194	238.8329	0.1215	243.0603
0.1080	216.0190	0.1316	263.1810	0.2044	408.7163	0.1316	263.1810	0.1373	274.5465
0.1148	229.6744	0.2129	425.8043	0.1888	377.6279	0.1427	285.4599	0.1173	234.5292
0.2330	465.9263	0.1277	255.3231	0.1445	289.0061	0.1335	267.0232	0.1034	206.8353
0.1407	281.3038	0.1658	331.6744	0.1215	243.0603	0.1902	380.3157	0.1277	255.3231
0.1442	288.4328	0.1034	206.8353	0.0984	196.7396	0.0930	186.0971	0.1194	238.8329
0.1624	324.8282	0.1151	230.1451	0.1445	289.0061	0.1173	234.5292	0.1151	230.1451
0.1844	368.7574	0.0814	162.7372	0.1391	278.2319	0.1719	343.7392	0.1531	306.1216
0.1407	281.3038	0.1564	312.7056	0.1277	255.3231	0.1875	374.9209	0.1445	289.0061
0.1424	284.8794	0.1128	225.6758	0.1354	270.8110	0.1059	211.7027	0.1409	281.8690
0.1442	288.4328	0.1354	270.8110	0.1354	270.8110	0.1514	302.7759	0.1316	263.1810
0.1388	277.6822	0.1215	243.0603	0.1082	216.4607	0.1954	390.8820	0.1463	292.5093
0.2498	499.5548	0.1497	299.3928	0.1236	247.2155	0.1082	216.4607	0.1627	325.4743
0.1254	250.7948	0.0844	168.8803	0.1445	289.0061	0.1277	255.3231	0.1082	216.4607
0.1670	334.0650	0.1463	292.5093	0.1257	251.3020	0.1915	382.9846	0.1106	221.1163
0.1442	288.4328	0.1335	267.0232	0.1719	343.7392	0.2612	522.4773	0.1173	234.5292
0.1885	376.9530	0.1194	238.8329	0.1409	281.8690	0.1354	270.8110	0.1719	343.7392

0.1332	266.4982	0.1612	322.3296	0.1993	398.6230	0.1409	281.8690	0.1034	206.8353
0.1670	334.0650	0.0984	196.7396	0.1373	274.5465	0.1658	331.6744	0.0957	191.4923
0.1608	321.6771	0.1612	322.3296	0.1277	255.3231	0.1915	382.9846	0.1612	322.3296
0.1494	298.7968	0.1354	270.8110	0.1128	225.6758	0.1316	263.1810	0.1547	309.4311
0.1126	225.2240	0.1409	281.8690	0.1335	267.0232	0.1564	312.7056	0.1128	225.6758
0.1759	351.8119	0.1082	216.4607	0.2141	428.1898	0.1059	211.7027	0.1373	274.5465
0.1170	234.0673	0.1059	211.7027	0.1391	278.2319	0.1497	299.3928	0.1009	201.8506
0.1511	302.1655	0.1354	270.8110	0.1888	377.6279	0.1497	299.3928	0.1151	230.1451
0.1460	291.9211	0.1034	206.8353	0.1354	270.8110	0.1445	289.0061	0.1335	267.0232
0.1715	343.0532	0.1277	255.3231	0.1257	251.3020	0.1215	243.0603	0.1277	255.3231
0.1407	281.3038	0.0984	196.7396	0.1257	251.3020	0.1514	302.7759	0.1531	306.1216
0.1460	291.9211	0.1689	337.7607	0.2141	428.1898	0.0930	186.0971	0.0874	174.8077
0.1788	357.5378	0.1194	238.8329	0.1967	393.4793	0.1954	390.8820	0.0930	186.0971
0.1274	254.8239	0.1082	216.4607	0.1257	251.3020	0.2006	401.1701	0.1514	302.7759
0.1511	302.1655	0.1009	201.8506	0.1354	270.8110	0.1480	295.9711	0.1427	285.4599
0.1830	365.9847	0.1151	230.1451	0.1316	263.1810	0.1409	281.8690	0.1059	211.7027
0.1148	229.6744	0.1059	211.7027	0.1316	263.1810	0.1082	216.4607	0.1194	238.8329
0.1494	298.7968	0.1902	380.3157	0.2257	451.3517	0.2188	437.6017	0.1833	366.6798
0.2646	529.1364	0.2583	516.5956	0.1791	358.2493	0.1888	377.6279	0.1059	211.7027
0.2341	468.1074	0.2573	514.6201	0.1463	292.5093	0.1128	225.6758	0.2105	420.9928
0.1313	262.6483	0.1082	216.4607	0.1335	267.0232	0.1373	274.5465	0.1391	278.2319
0.2274	454.8642	0.1689	337.7607	0.1236	247.2155	0.1034	206.8353	0.1409	281.8690
0.1424	284.8794	0.1967	393.4793	0.2279	455.8428	0.2141	428.1898	0.1819	363.8913
0.1388	277.6822	0.1777	355.3947	0.2081	416.1257	0.1580	315.9462	0.1106	221.1163
0.1788	357.5378	0.1151	230.1451	0.1296	259.2818	0.1463	292.5093	0.1902	380.3157
0.1511	302.1655	0.1257	251.3020	0.1335	267.0232	0.1791	358.2493	0.1151	230.1451
0.1715	343.0532	0.1236	247.2155	0.1497	299.3928	0.1354	270.8110	0.1514	302.7759
0.1351	270.2698	0.1215	243.0603	0.1531	306.1216	0.1580	315.9462	0.1082	216.4607
0.1332	266.4982	0.1151	230.1451	0.1497	299.3928	0.1445	289.0061	0.1391	278.2319
0.1494	298.7968	0.1335	267.0232	0.2583	516.5956	0.1643	328.5890	0.1059	211.7027
0.1388	277.6822	0.1689	337.7607	0.2462	492.3665	0.1373	274.5465	0.0844	168.8803
0.1528	305.5179	0.1215	243.0603	0.1151	230.1451	0.1215	243.0603	0.1082	216.4607
0.1511	302.1655	0.1391	278.2319	0.1277	255.3231	0.1480	295.9711	0.1847	369.4473
0.1544	308.8133	0.1427	285.4599	0.1173	234.5292	0.1763	352.5169	0.1564	312.7056
0.1730	345.9913	0.1296	259.2818	0.1445	289.0061	0.1373	274.5465	0.1151	230.1451
0.1528	305.5179	0.1612	322.3296	0.1354	270.8110	0.1733	346.6898	0.1497	299.3928
0.1254	250.7948	0.2388	477.6657	0.1335	267.0232	0.1128	225.6758	0.1627	325.4743

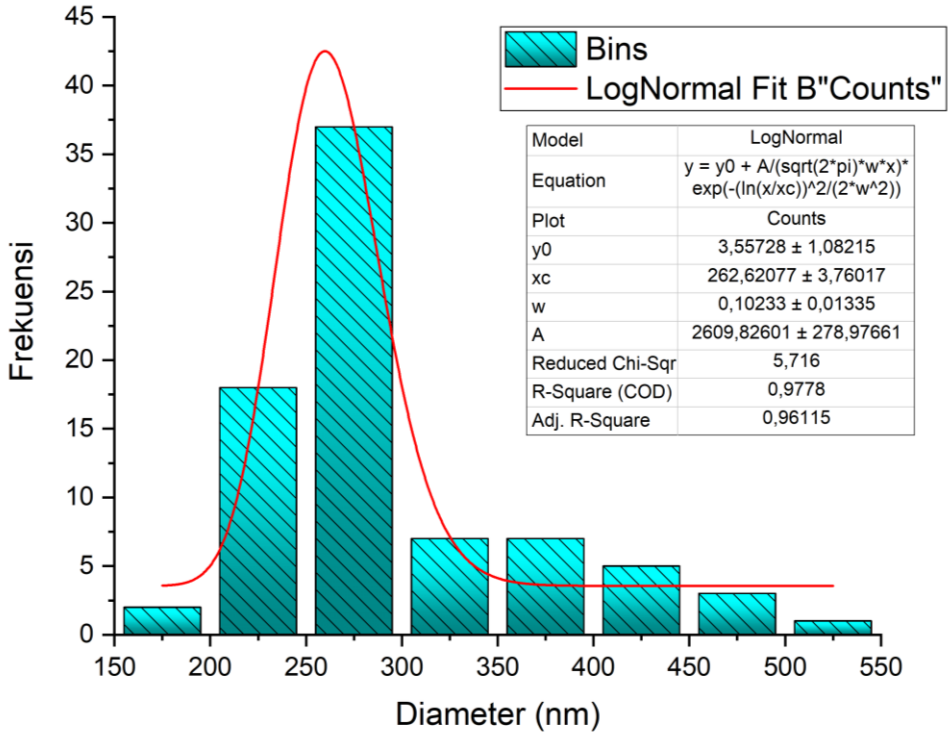
- HZSM-5 (C)



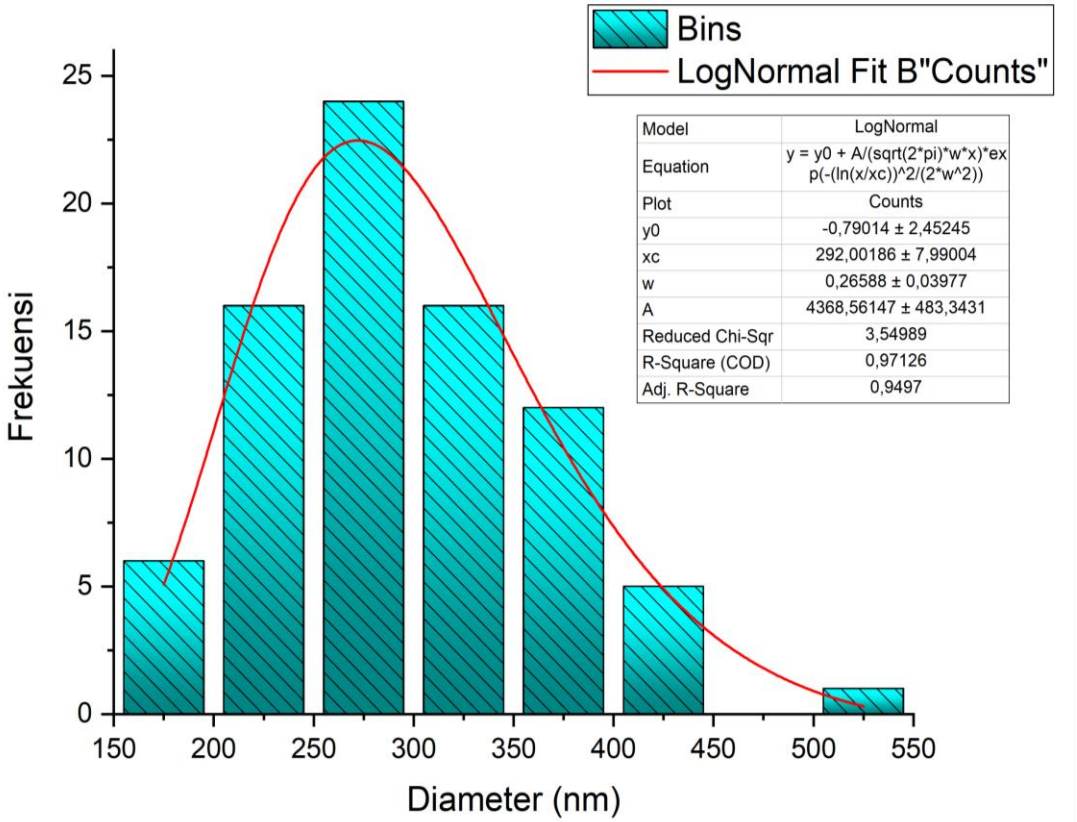
- HZSM-5 (S)



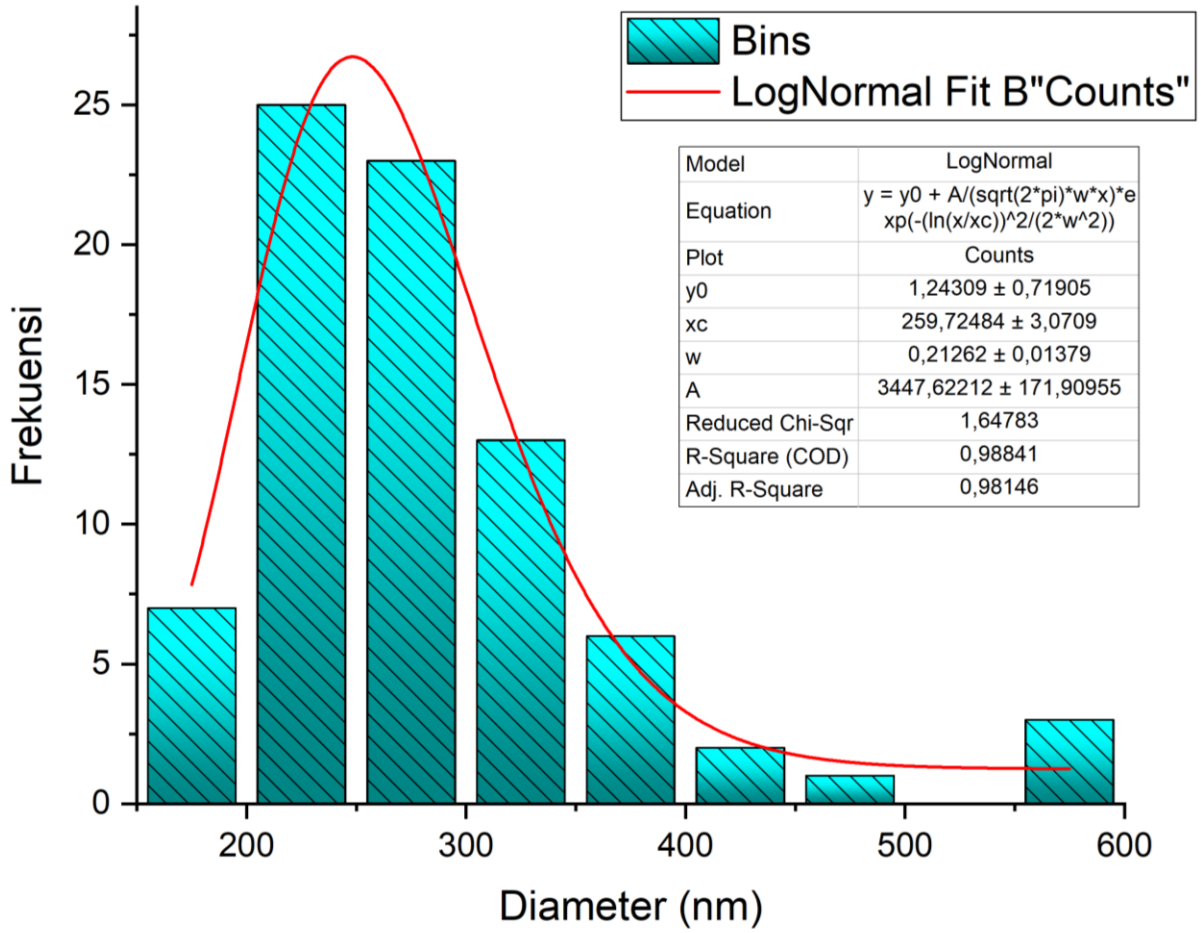
- Ni-Zr/HZ (1:1)



- Ni-Zr/HZ (1:2)



- Ni-Zr/HZ (2:1)


Bins
LogNormal Fit B"Counts"
Model LogNormal
Equation y = y0 + A/(sqrt(2*pi)*w*x)*exp(-(ln(x/xc))^2/(2*w^2))
Plot Counts
y0 1,24309 ± 0,71905
xc 259,72484 ± 3,0709
w 0,21262 ± 0,01379
A 3447,62212 ± 171,90955
Reduced Chi-Sqr 1,64783
R-Square (COD) 0,98841
Adj. R-Square 0,98146
Frekuensi
0
5
10
15
20
25
200
300
400
500
600
Diameter (nm)

Brunauer-Emmett-Teller (BET)

HZSM-5 (C)				HZSM-5 (S)			
P/Po	Ads	P/Po	Des	P/Po	Ads	P/Po	Des
0.004801	72.2275	0.98881	122.7517	0.00477	84.1126	0.990474	135.2577
0.009998	73.8716	0.910453	105.3046	0.009689	84.9914	0.949697	122.9739
0.01957	76.3243	0.900416	105.0334	0.018863	85.9351	0.898087	121.11
0.028708	78.377	0.850323	104.0715	0.029209	86.6831	0.848745	120.2316
0.039737	80.6012	0.799333	103.4174	0.039453	87.3065	0.798752	119.5102
0.049523	82.2847	0.750045	102.9298	0.048968	87.8414	0.751033	118.9358
0.100537	87.7197	0.698455	102.4401	0.098844	90.5416	0.698258	118.3278
0.149752	90.3093	0.649896	101.9181	0.150445	93.5354	0.649174	117.829
0.199228	91.8911	0.598201	101.0882	0.199933	99.44	0.598179	117.3899
0.249494	93.0107	0.546068	99.7461	0.248683	101.9363	0.549215	116.9253
0.301202	93.8659	0.499151	98.6868	0.299779	103.3481	0.501155	116.2554
0.351429	94.5016	0.446755	96.0977	0.349253	104.3572	0.449376	107.2445
0.39982	95.026	0.400703	95.4608	0.401119	105.197	0.400664	105.9399
0.451297	95.4916	0.350573	94.894	0.449812	105.8691	0.348869	104.8979
0.499935	95.901	0.298389	94.2	0.499222	106.4679	0.297702	103.8937
0.548953	96.2928	0.245961	93.3065	0.551401	107.0591	0.249308	102.6825
0.60626	96.7514	0.195494	92.1475	0.602316	107.5969	0.200123	101.0027
0.650133	97.1057	0.149025	90.6038	0.650235	108.1491	0.151214	98.091
0.703369	97.6032	0.098288	87.8675	0.701622	108.7661	0.099454	90.8509
0.753917	98.0878	0.050279	83.0998	0.752369	109.5126	0.050939	88.3996
0.802206	98.6642	0.040598	81.4471	0.798773	110.3307	0.040759	87.8249
0.852019	99.5425	0.030185	79.3731	0.850478	111.5448	0.030601	87.224
0.899789	100.7964	0.021104	77.3136	0.899547	113.2165	0.020759	86.5532
0.951045	103.8958	0.009181	74.1365	0.948917	116.5191	0.010247	85.6004
0.999001	142.7121			0.999281	144.2526		

Ni-Zr/HZ (1:1)				Ni-Zr/HZ (1:2)			
P/Po	Ads	P/Po	Des	P/Po	Ads	P/Po	Des
0.004842	88.6715	0.991751	147.0409	0.004873	74.7754	0.989982	118.0386
0.009772	89.6133	0.945264	128.4685	0.009636	75.4725	0.947649	102.3194
0.019651	90.7517	0.898082	127.231	0.018951	76.3163	0.898382	101.4689
0.029252	91.5625	0.847955	126.7157	0.029395	76.9816	0.847383	101.0512
0.039414	92.3101	0.798956	126.3047	0.039626	77.5209	0.797696	100.7301
0.048837	92.973	0.748554	125.9239	0.049659	78.0156	0.749776	100.429
0.099349	96.5532	0.700344	125.4658	0.098995	80.1179	0.696986	100.0736
0.149058	100.3211	0.645066	124.8525	0.149367	82.2017	0.649624	99.758
0.199136	103.6161	0.600386	124.2697	0.200141	85.0015	0.598238	99.4133
0.248675	106.1813	0.550735	123.5898	0.249322	87.669	0.548878	99.0447
0.299433	108.0116	0.501341	120.3841	0.29956	88.9993	0.500976	98.367
0.350435	109.4307	0.449022	112.3428	0.348968	89.9264	0.447814	92.59
0.400726	110.534	0.398773	110.9487	0.399936	90.7048	0.398915	91.4509
0.450307	111.4743	0.349032	109.7887	0.454549	91.3846	0.347738	90.5527

0.499213	112.3008	0.299007	108.4678	0.498755	91.8749	0.297166	89.6239
0.559632	113.2657	0.250131	106.7516	0.550106	92.4385	0.250057	88.5134
0.600758	113.9182	0.200023	104.3203	0.600214	92.9197	0.200587	86.804
0.651613	114.6402	0.151172	100.976	0.651287	93.4129	0.150635	83.6181
0.69992	115.361	0.100705	96.9859	0.70033	93.9247	0.10087	80.628
0.749575	116.0264	0.050488	93.5471	0.748942	94.4466	0.050609	78.5955
0.801311	116.7332	0.040986	92.8577	0.801008	95.1072	0.040116	78.0732
0.851615	117.4768	0.031113	92.1165	0.850841	95.94	0.030125	77.5355
0.90122	118.2714	0.020888	91.2793	0.900154	97.021	0.020294	76.9015
0.950229	120.0272	0.010369	90.0759	0.950381	99.1258	0.009781	76.1455
0.998072	172.86			0.998551	165.7106		

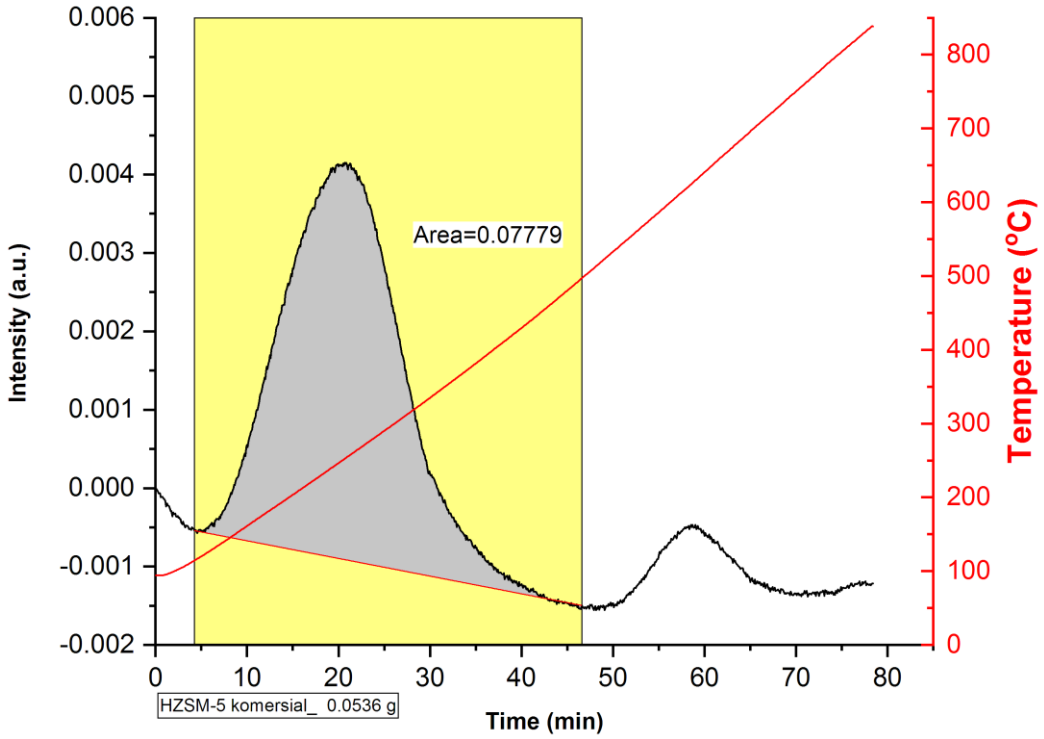
Ni-Zr/HZ (2:1)			
P/Po	**Ads**	**P/Po**	**Des**
0.004799	65.3671	0.991238	108.5967
0.009729	66.1863	0.949666	94.5707
0.020013	67.2353	0.900227	93.0713
0.030331	67.97	0.850037	92.3665
0.038754	68.4957	0.800511	91.8427
0.050565	69.1679	0.749861	91.4009
0.099452	71.7421	0.698249	90.9884
0.149481	74.2521	0.649936	90.63
0.200136	77.4252	0.59997	90.2247
0.249437	79.8653	0.549474	89.8159
0.300149	81.2393	0.499355	89.0705
0.349192	82.2606	0.449068	84.4852
0.400605	83.0804	0.398932	83.3964
0.452504	83.8084	0.347151	82.454
0.499159	84.3593	0.297706	81.5024
0.549783	84.9111	0.249644	80.3291
0.559031	85.4538	0.200819	78.6506
0.649986	85.9777	0.150535	75.6148
0.701868	86.5089	0.101167	72.1238
0.751625	87.0904	0.051289	69.6393
0.799007	87.6836	0.040462	69.013
0.851453	88.5578	0.030459	68.3824
0.900946	89.8515	0.020519	67.6639
0.950844	92.3672	0.010374	66.7814
0.997836	119.5471		

Barrett-Joyner-Halenda (BJH)

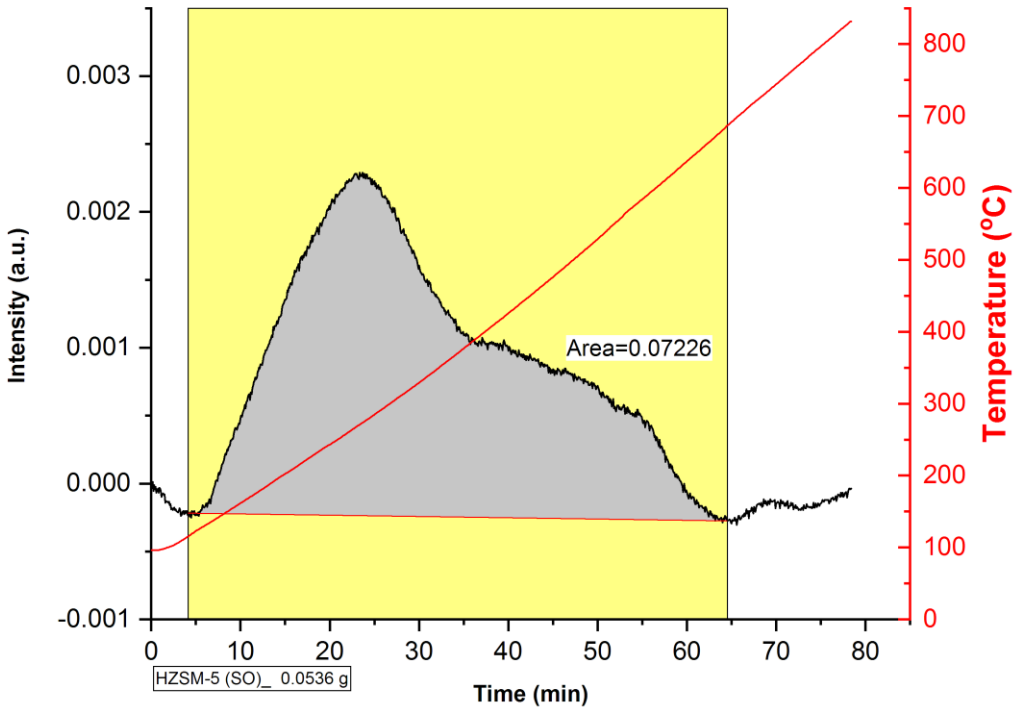
HZSM-5 (C)		HZSM-5 (S)		Ni-Zr/HZ (1:1)		Ni-Zr/HZ (1:2)		Ni-Zr/HZ (2:1)	
D (nm)	dV(d)	D (nm)	dV(d)	D (nm)	dV(d)	D (nm)	dV(d)	D (nm)	dV(d)
3,063	0,002378	3,417	0,00636	3,409	0,006153	3,404	0,006714	3,410	0,006486
3,406	0,003221	3,833	0,063763	3,833	0,055098	3,826	0,039709	3,823	0,033188
3,813	0,016935	4,318	0,003422	4,327	0,01851	4,315	0,003672	4,312	0,003807
4,290	0,005722	4,885	0,001674	4,909	0,00263	4,883	0,001338	4,901	0,001443
4,867	0,005442	5,608	0,001118	5,586	0,001956	5,612	0,000883	5,628	0,0011
5,614	0,002432	6,530	0,001023	6,518	0,001186	6,519	0,000639	6,537	0,000717
6,539	0,001097	7,802	0,000827	7,785	0,000672	7,766	0,00044	7,782	0,000542
7,788	0,00064	9,569	0,00056	9,532	0,000312	9,520	0,000245	9,595	0,00038
9,567	0,000424	12,274	0,000403	12,244	0,000198	12,186	0,000137	12,378	0,000273
12,360	0,000331	17,202	0,000245	17,166	0,000116	17,170	8,24E-05	17,470	0,000178
17,502	0,000249	30,324	0,000165	28,756	0,000121	29,596	6,71E-05	30,522	0,000132
22,010	0,000213	121,955	0,000123	135,950	0,000152	116,265	0,000165	130,716	0,000126
98,467	0,00019	1434,213	5,7E-06	615,176	5,33E-05	758,765	6,61E-05	554,113	2,59E-05
1045,983	1,79E-05								

NH_3-TPD

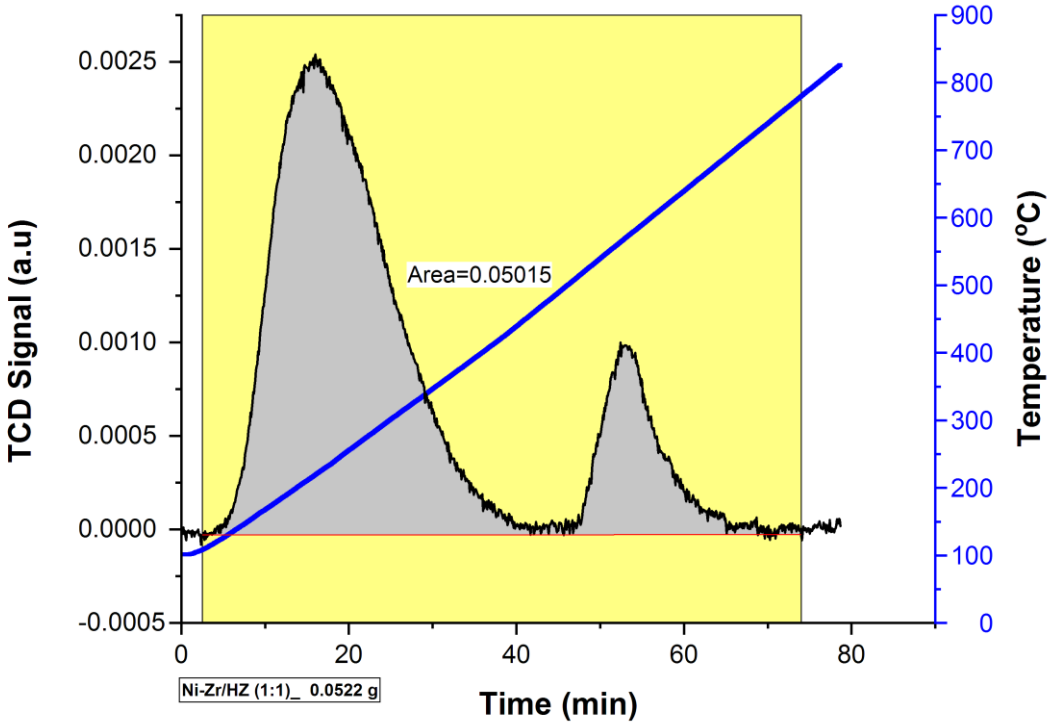
- HZSM-5 (C)



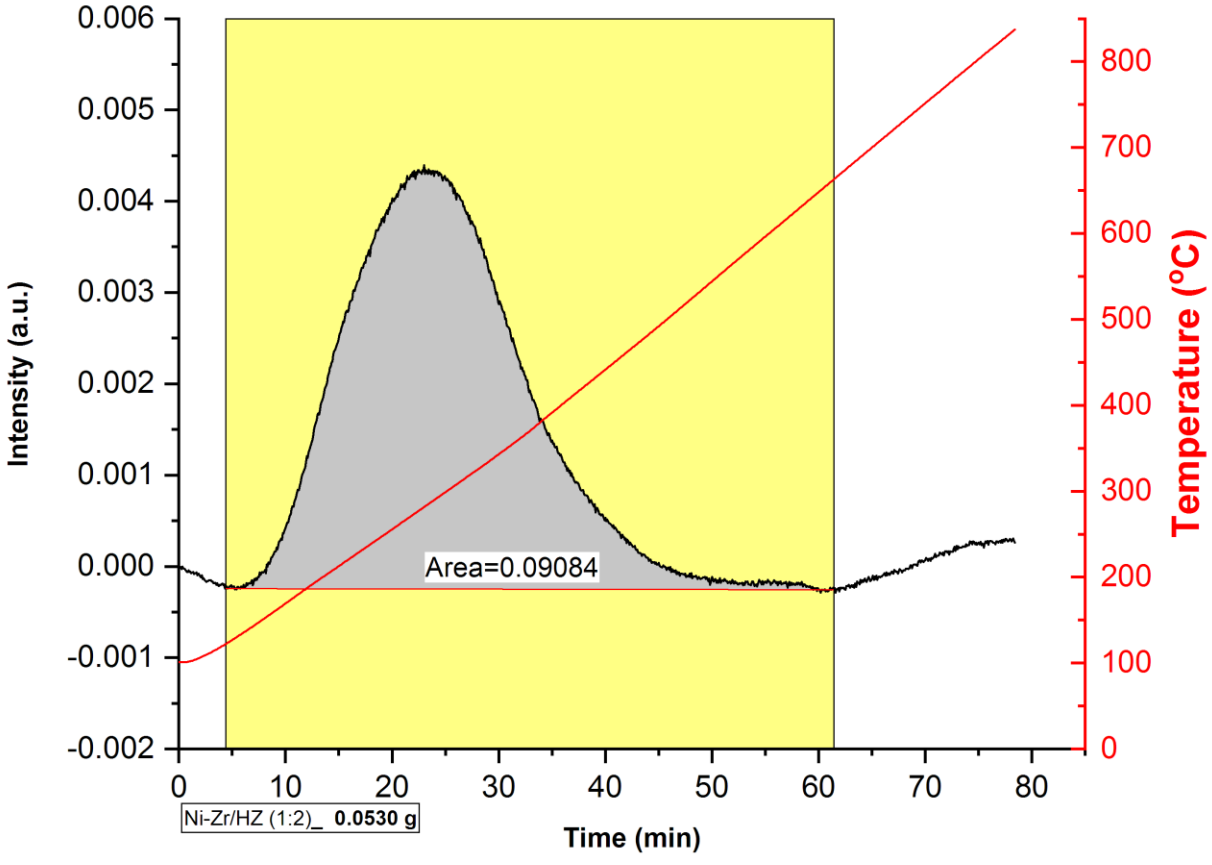
- HZSM-5 (S)



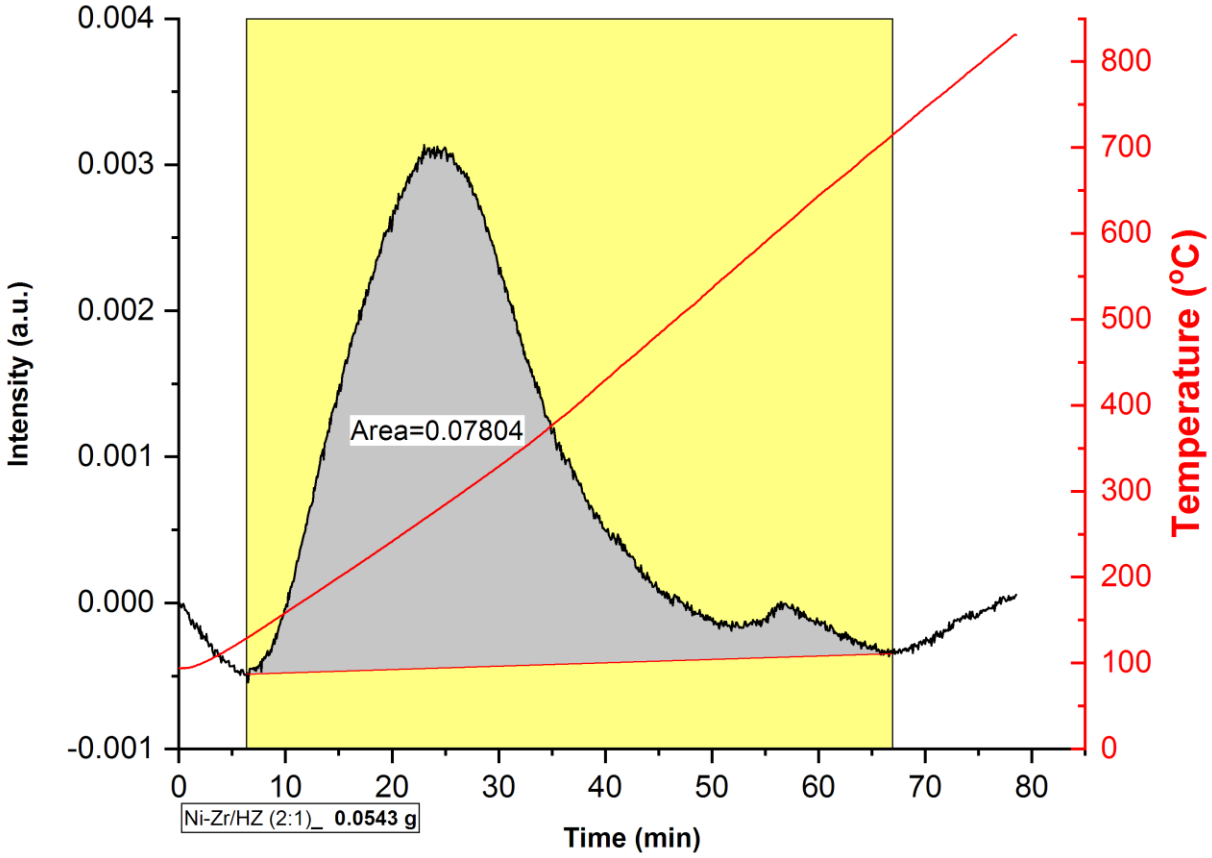
- Ni-Zr/HZ (1:1)



- Ni-Zr/HZ (1:2)



- Ni-Zr/HZ (2:1)


0.004
0.003
0.002
0.001
0.000
-0.001
Intensity (a.u.)
Area=0.07804
0
10
20
30
40
50
60
70
80
Time (min)
Ni-Zr/HZ (2:1)_ 0.0543 g
800
700
600
500
400
300
200
100
0
Temperature (°C)

GENERAL LINEAR MODEL

KATALIS DAN WAKTU

General Linear Model: Yield versus Katalis; Waktu Reaksi

Method

Factor coding	(-1; 0; +1)

Factor Information

Factor	Type	Levels	Values
Katalis	Fixed	5	HZSM-5 (C); HZSM-5 (S); Ni-Zr/HZ (1:1); Ni-Zr/HZ (1:2); Ni-Zr/HZ (2:1)
Waktu Reaksi	Fixed	2	3; 5

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Katalis	4	330,547	82,637	59,85	0,001
Waktu Reaksi	1	14,544	14,544	10,53	0,032
Error	4	5,523	1,381		
Total	9	350,614			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1,17504	98,42%	96,46%	90,16%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	76,014	0,372	204,57	0,000	
Katalis					
HZSM-5 (C)	-8,069	0,743	-10,86	0,000	1,60
HZSM-5 (S)	-4,129	0,743	-5,56	0,005	1,60
Ni-Zr/HZ (1:1)	1,931	0,743	2,60	0,060	1,60
Ni-Zr/HZ (1:2)	1,481	0,743	1,99	0,117	1,60
Waktu Reaksi					
3	-1,206	0,372	-3,25	0,032	1,00

Regression Equation

Yield = 76,014 - 8,069 Katalis_HZSM-5 (C) - 4,129 Katalis_HZSM-5 (S) + 1,931 Katalis_Ni-Zr/HZ (1:1) + 1,481 Katalis_Ni-Zr/HZ (1:2) + 8,786 Katalis_Ni-Zr/HZ (2:1) - 1,206 Waktu Reaksi_3 + 1,206 Waktu Reaksi_5

YIELD

HZSM-5 (C)					
Reaction time	**Oil weight**	**Bottle weight**	**Oil + Bottle weight**	**Biodiesel weight**	**Yield**
3 jam	40	30,4047	56,5327	26,1280	65,32
5 jam	40	30,4047	58,6315	28,2268	70,57

HZSM-5 (S)					
Reaction time	**Oil weight**	**Bottle weight**	**Oil + Bottle weight**	**Biodiesel weight**	**Yield**
3 jam	40	30,5190	58,9470	28,4280	71,07
5 jam	40	30,5190	59,5991	29,0801	72,70

Ni-Zr/HZ (1:1)					
Reaction time	**Oil weight**	**Bottle weight**	**Oil + Bottle weight**	**Biodiesel weight**	**Yield**
3 jam	40	30,4164	61,1044	30,6880	76,72
5 jam	40	30,4164	62,0859	31,6695	79,17

Ni-Zr/HZ (1:2)					
Reaction time	**Oil weight**	**Bottle weight**	**Oil + Bottle weight**	**Biodiesel weight**	**Yield**
3 jam	40	30,6358	61,2998	30,664	76,66
5 jam	40	30,6358	61,9682	31,3324	78,33

Ni-Zr/HZ (2:1)					
Reaction time	**Oil weight**	**Bottle weight**	**Oil + Bottle weight**	**Biodiesel weight**	**Yield**
3 jam	40	30,6531	64,3611	33,7080	84,27
5 jam	40	30,6531	64,7866	34,1335	85,33