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APPENDICES

Appendix A The Calculated Volume of the Manifold and Sample Holder

Table A1 Manifold volume estimated by gas expansion

Experiment	P initial (psia)	P final (psia)	Volume (cm ³)
1	133.13	101.52	19.24
2	196.88	159.83	19.23
3	116.25	85.76	19.24
4	140.63	109.06	19.22
5	133.13	105.63	19.24
Average			19.24

Table A2 Dead volume of the sample holder

Experiment	P initial (psia)	P final (psia)	Volume (cm ³)
S1	1454.945	731.136	31.34
S2	1389.744	695.971	31.49
S3	1372.894	684.982	31.70
S4	1447.619	706.960	33.16
S5	1427.839	716.484	31.43
S6	1389.744	694.505	31.68
S7	1331.25	639.375	21.95
S8	1308.75	624.375	22.22
S9	1419.78	706.96	31.88
S10	1473.26	733.066	31.98
S11	1462.5	699.375	22.19
S12	1312.5	628.125	22.09

Appendix B Desorbed and absorbed hydrogen calculation

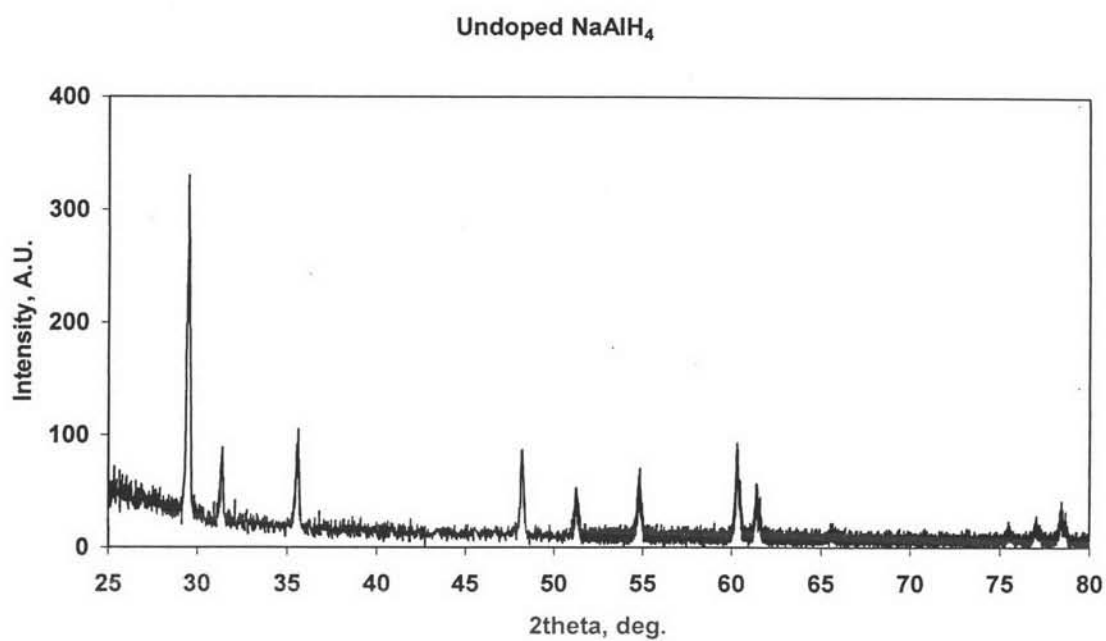
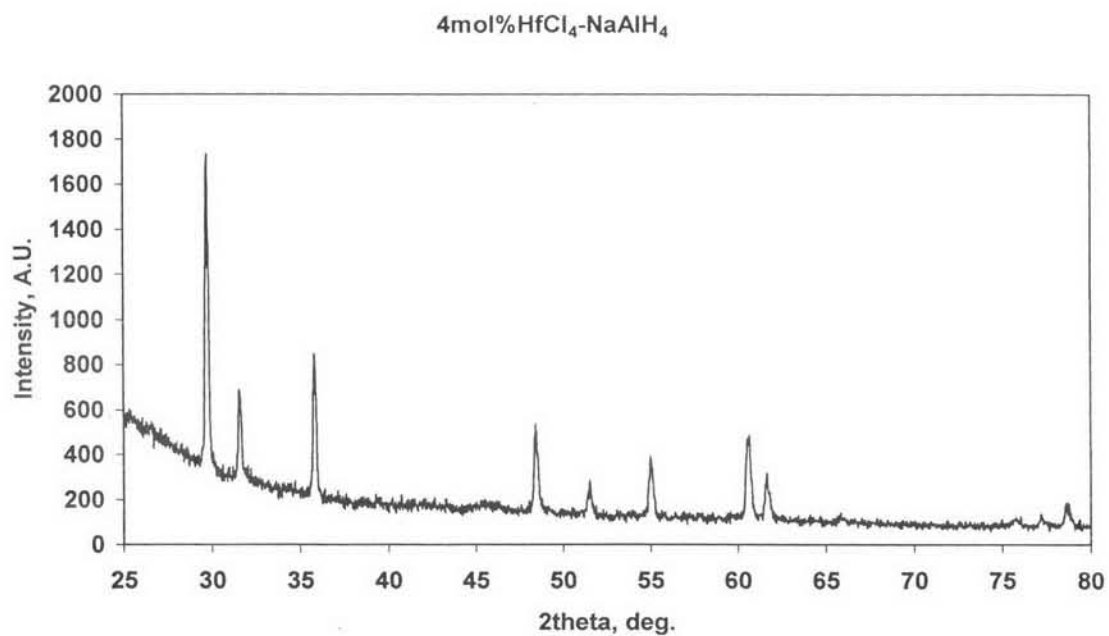
For example: at 4mol%Ni-HfCl₄-NaAlH₄

Table B1 Desorbed hydrogen calculated capacity from Equation of State with compressibility factor

Temperature(°C)	P(atm)	Z	mol H ₂	wt% (H/M)
88.2	0.003181	0.999475	9.51208E-05	0.074157
98.8	0.00309	0.999575	9.24007E-05	0.072036
109.7	0.003002	0.999575	8.977E-05	0.069985
121.3	0.005825	0.999813	0.000174219	0.135822
132.7	0.005662	0.999813	0.000169325	0.132007
144.6	0.010999	1.000025	0.000328933	0.256439
156.1	0.013379	1.000081	0.000400129	0.311944
166.9	0.015658	1.000238	0.000468297	0.365088
172.8	0.018025	1.000294	0.000539088	0.420277
186.4	0.022487	1.000406	0.000672525	0.524306
195.3	0.026959	1.000519	0.000806268	0.628573
203.2	0.038552	1.0008	0.00115298	0.898872
210.8	0.045054	1.000969	0.001347435	1.050471
217.6	0.0561	1.00135	0.001677801	1.308027
224	0.066897	1.001631	0.002000682	1.559747
230	0.077473	1.001913	0.002317005	1.806355
235.4	0.085649	1.002138	0.002561521	1.996982
240.6	0.095911	1.002419	0.00286842	2.236243
245.5	0.106022	1.0027	0.003170817	2.471994
250.1	0.118187	1.003038	0.003534619	2.755617
254.4	0.132367	1.003431	0.003958712	3.086243
258.2	0.148589	1.003881	0.00444387	3.464476
261.7	0.162529	1.004275	0.004860761	3.789487
265	0.174226	1.004613	0.005210594	4.06222

Temperature(°C)	P(atm)	Z	mol H ₂	wt% (H/M)
267.9	0.181705	1.004838	0.005434261	4.236593
270.6	0.187078	1.005006	0.005594964	4.361878
273	0.192502	1.005175	0.005757176	4.48834
275.1	0.200057	1.0054	0.005983138	4.664502
277	0.203497	1.005513	0.006086012	4.744703
278.7	0.209046	1.005681	0.006251947	4.874067
280.3	0.212545	1.005794	0.006356605	4.955659
281.8	0.216062	1.005906	0.006461796	5.037667
283	0.217637	1.005963	0.006508897	5.074388
284.3	0.219166	1.006019	0.006554613	5.110028
285.2	0.220845	1.006075	0.006604838	5.149184
286	0.222559	1.006131	0.006656085	5.189136
286.8	0.224267	1.006188	0.006707178	5.228969
287.8	0.227912	1.0063	0.00681619	5.313956
288.3	0.229729	1.006356	0.006870541	5.356328
288.8	0.231543	1.006413	0.006924788	5.398619
289.1	0.233437	1.006469	0.006981414	5.442765
289.3	0.233354	1.006469	0.006978931	5.44083
289.6	0.235244	1.006525	0.007035472	5.484909
289.8	0.237175	1.006581	0.007093205	5.529919
290	0.239103	1.006638	0.00715089	5.574891

Appendix C XRD patterns

Fig. C1 XRD patterns of undoped NaAlH₄ before desorption.Fig. C2 XRD patterns of 4mol%HfCl₄- NaAlH₄ before desorption.

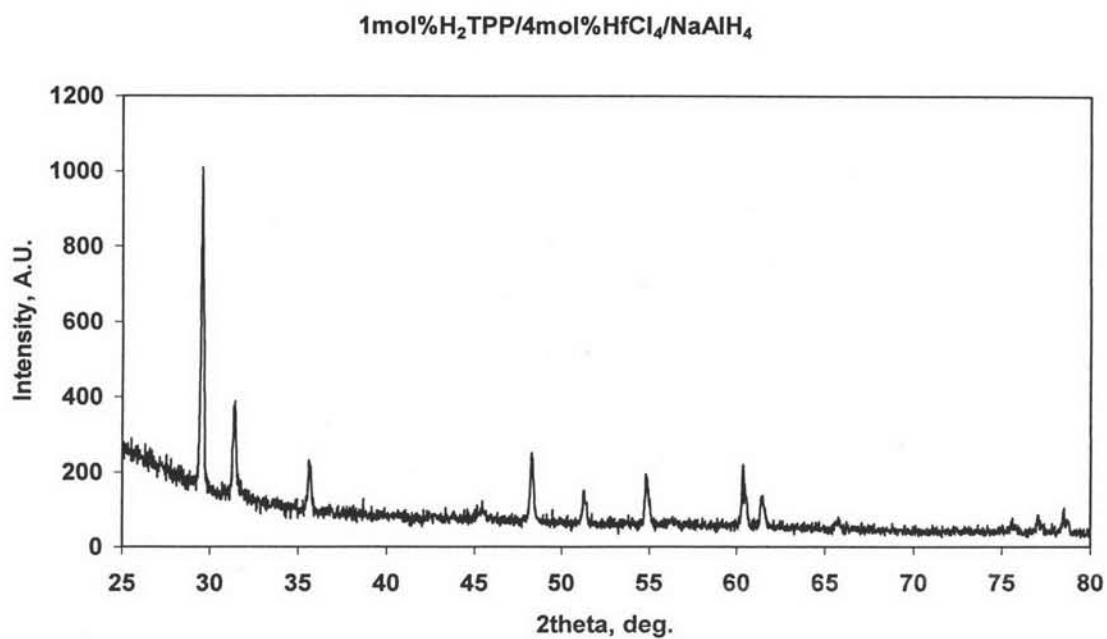


Fig. C3 XRD patterns of 1mol% H_2 TPP/4mol%HfCl₄/ NaAlH₄ before desorption.

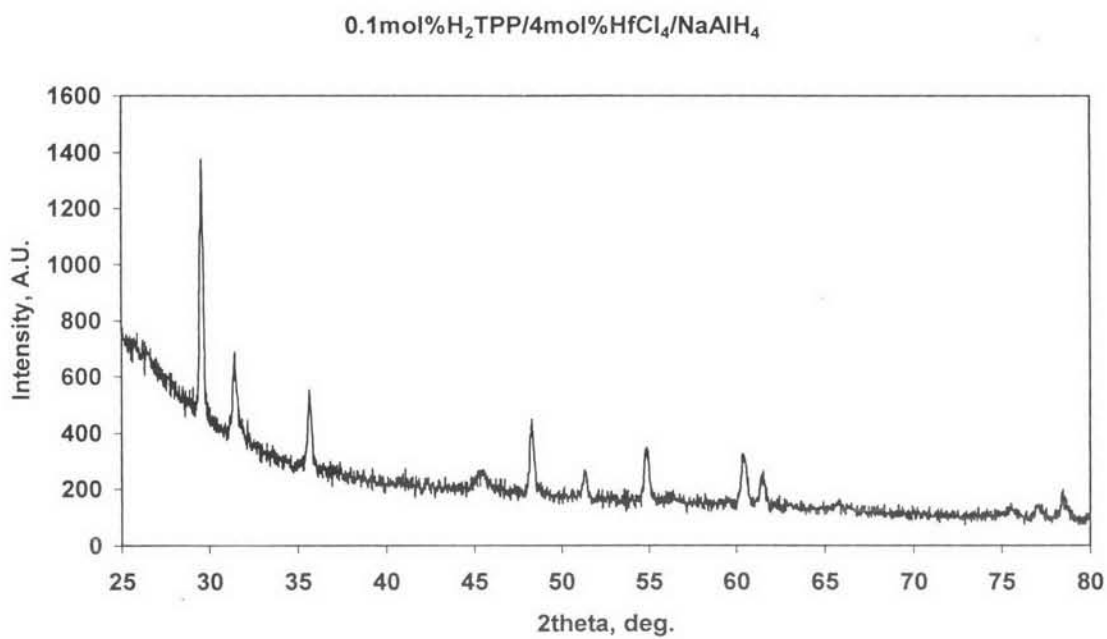


Fig. C4 XRD patterns of 0.1mol% H_2 TPP/4mol%HfCl₄/ NaAlH₄ before desorption.

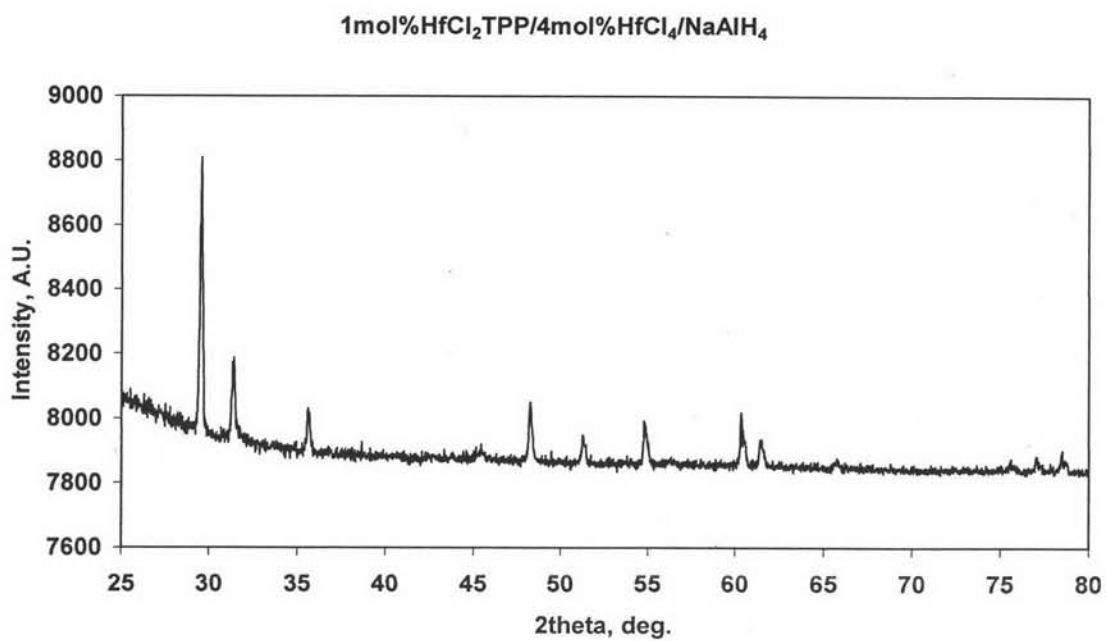


Fig. C5 XRD patterns of 1mol%HfCl₂TPP/4mol%HfCl₄/ NaAlH₄ before desorption.

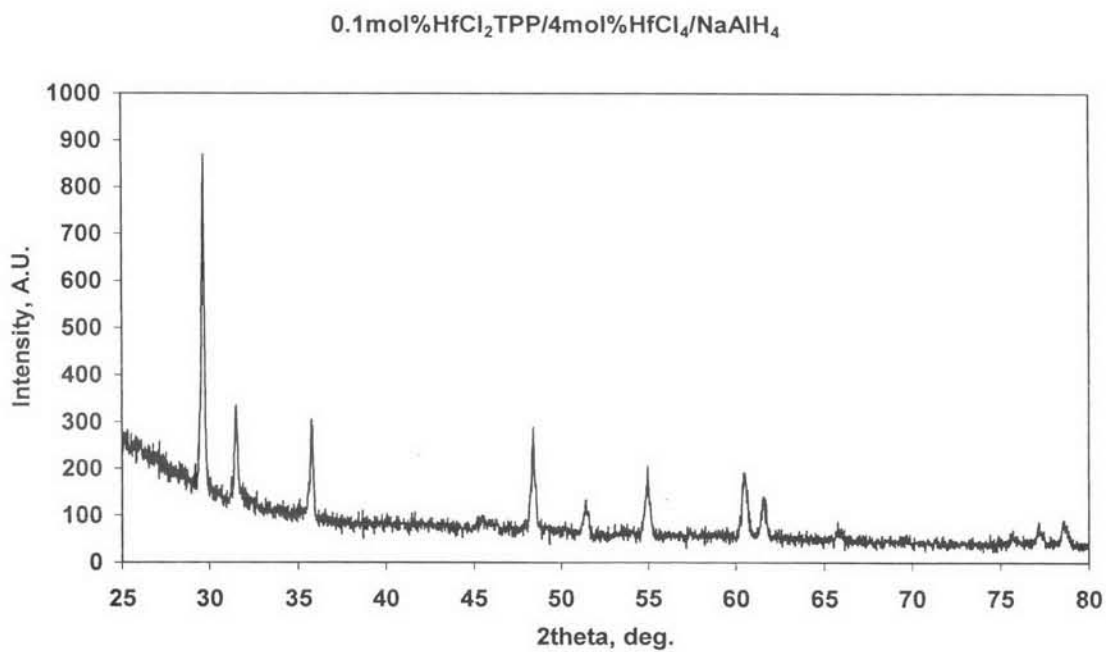


Fig. C6 XRD patterns of 0.1mol%HfCl₂TPP/4mol%HfCl₄/ NaAlH₄ before desorption.

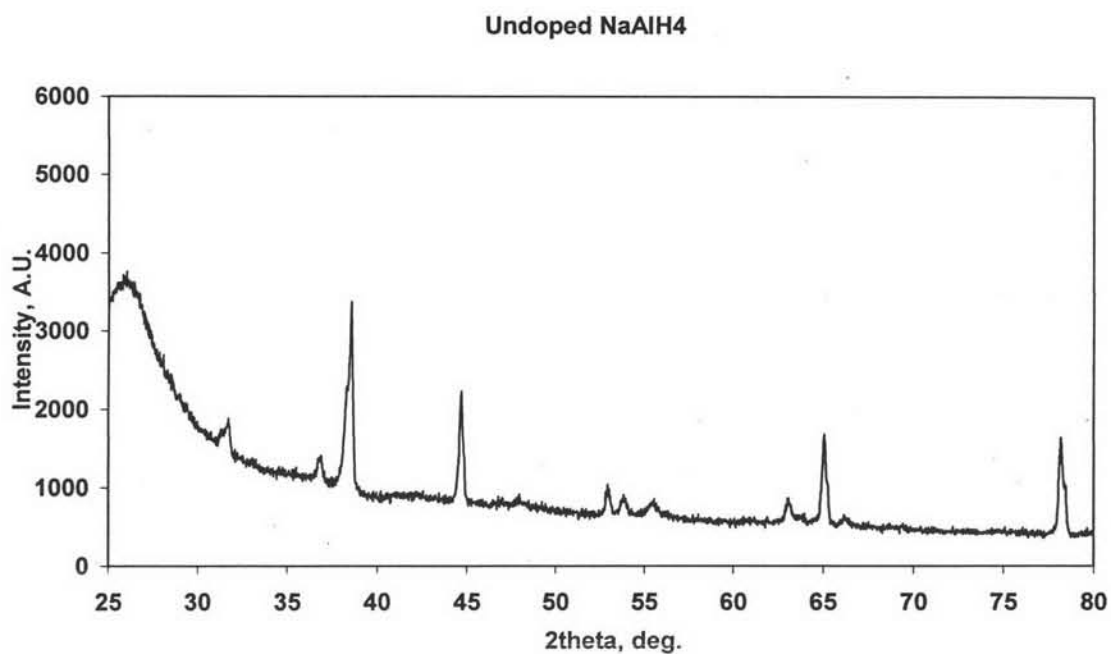


Fig. C7 XRD patterns of undoped NaAlH₄ after desorption.

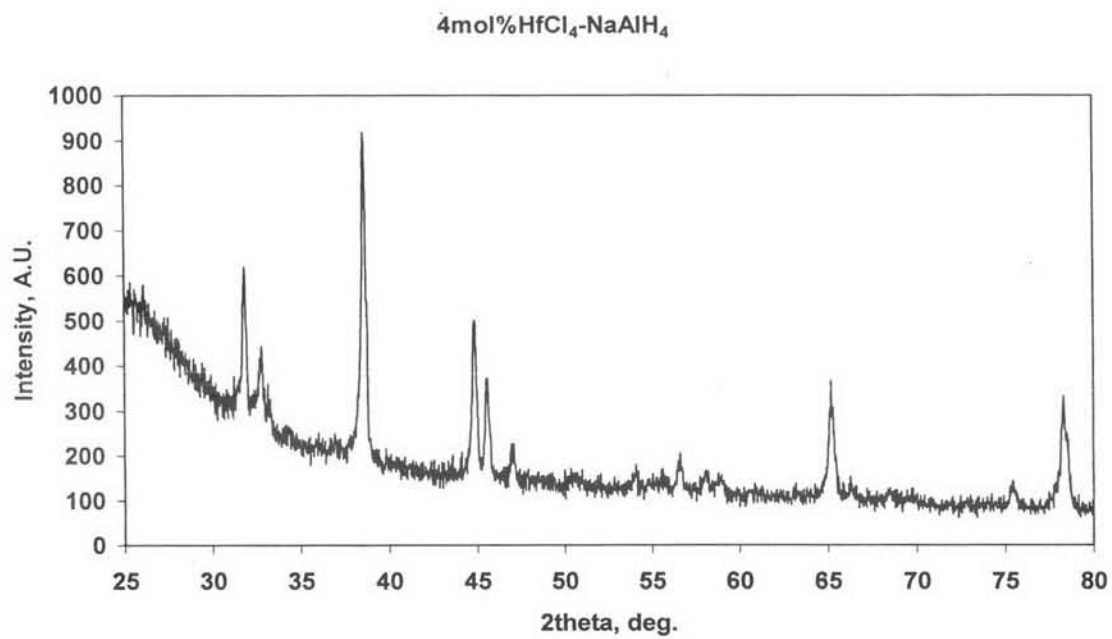


Fig. C8 XRD patterns of 4mol%HfCl₄- NaAlH₄ after desorption.

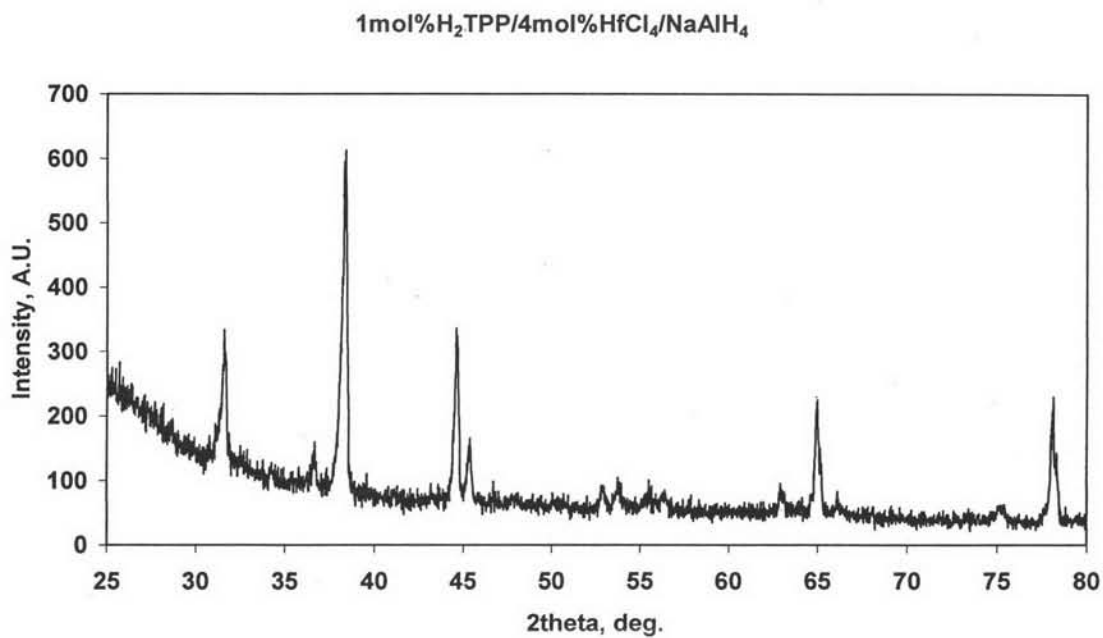


Fig. C9 XRD patterns of 1mol% H_2 TPP/4mol%HfCl₄/ NaAlH₄ after desorption.

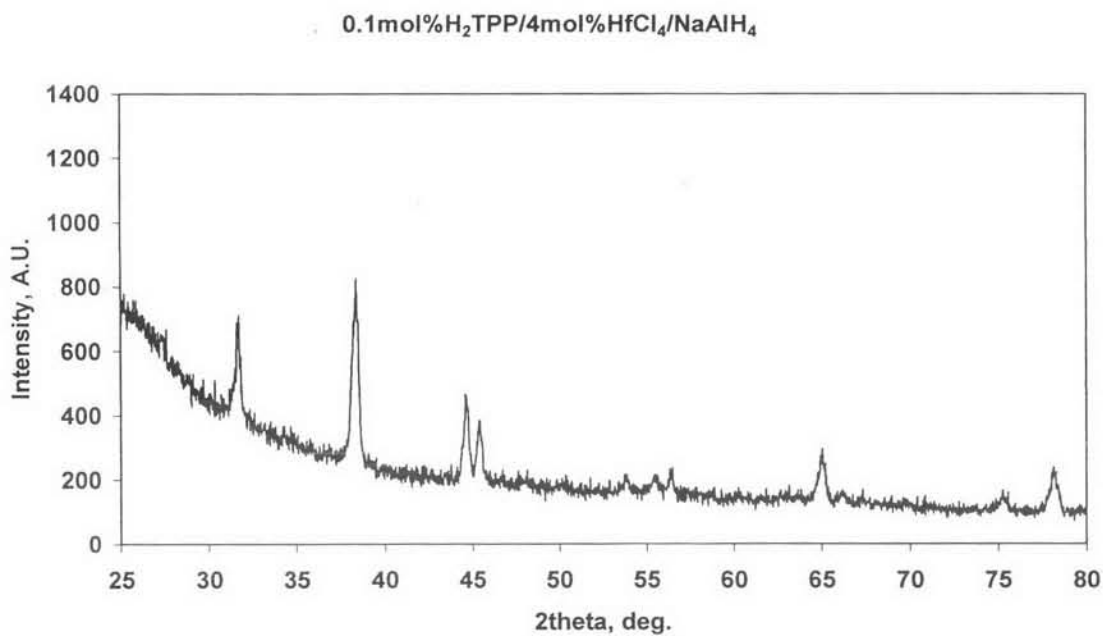


Fig. C10 XRD patterns of 0.1mol% H_2 TPP/4mol%HfCl₄/ NaAlH₄ after desorption.

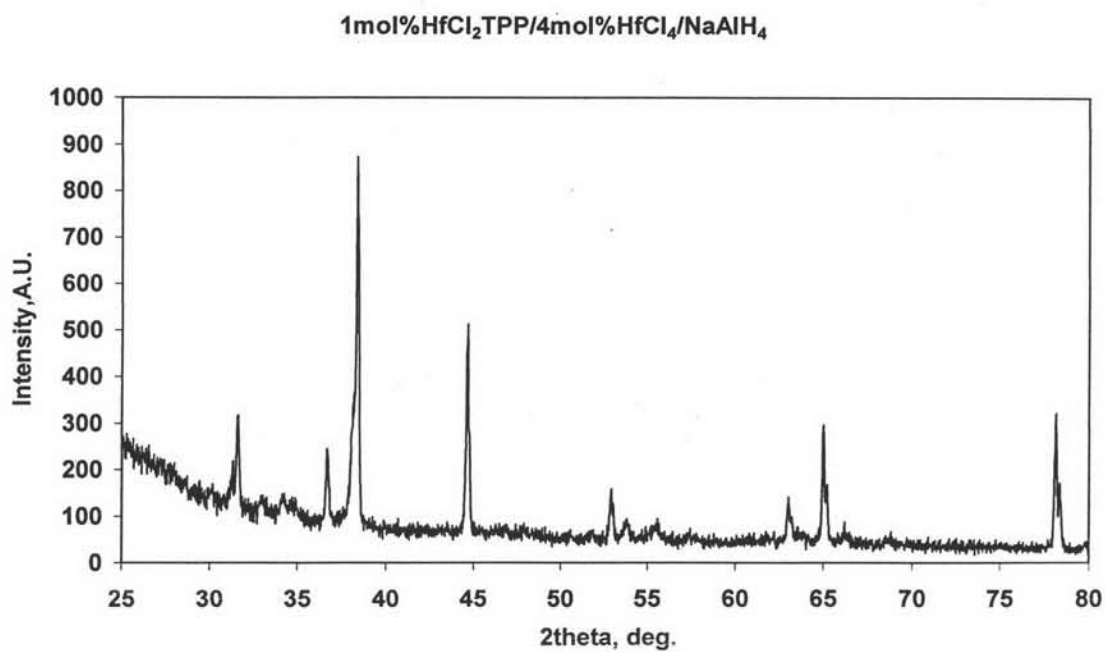


Fig. C11 XRD patterns of 1mol%HfCl₂TPP/4mol%HfCl₄/ NaAlH₄ after desorption.

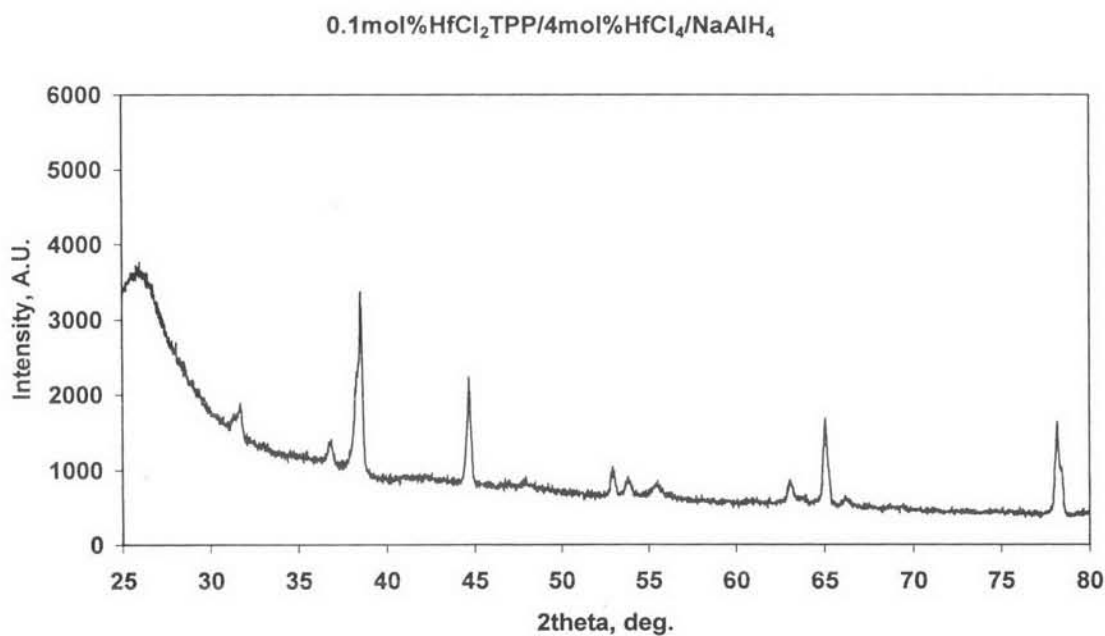


Fig. C12 XRD patterns of 0.1mol%HfCl₂TPP/4mol%HfCl₄/ NaAlH₄ after desorption.

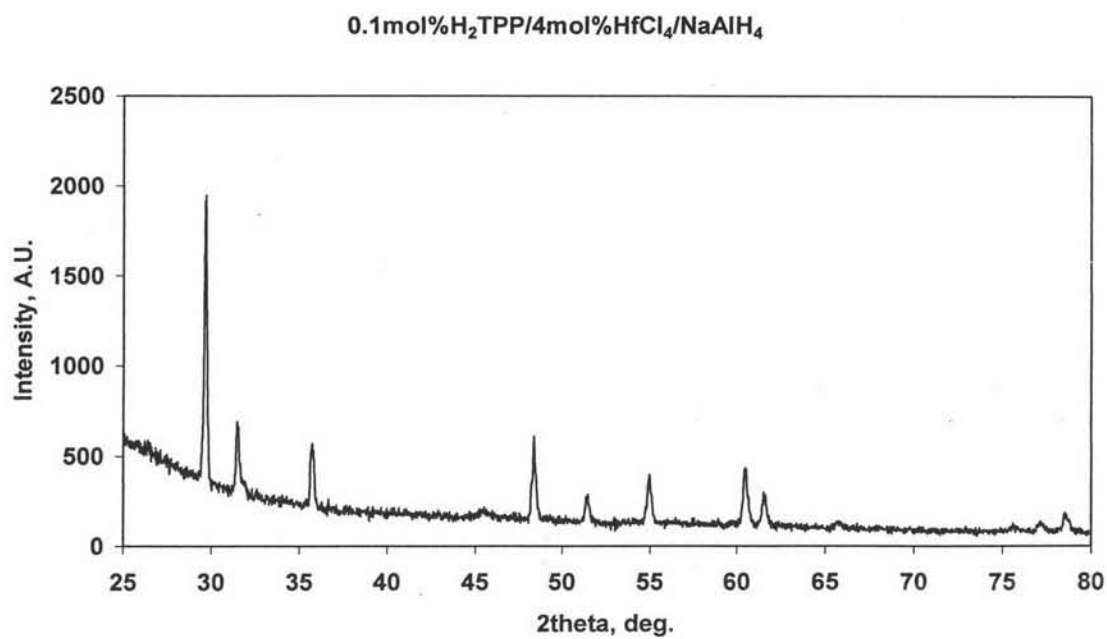


Fig. C13 XRD patterns of 0.1mol% $HfCl_2$ TPP added after mixed 4mol% $HfCl_4$ - $NaAlH_4$ before desorption.

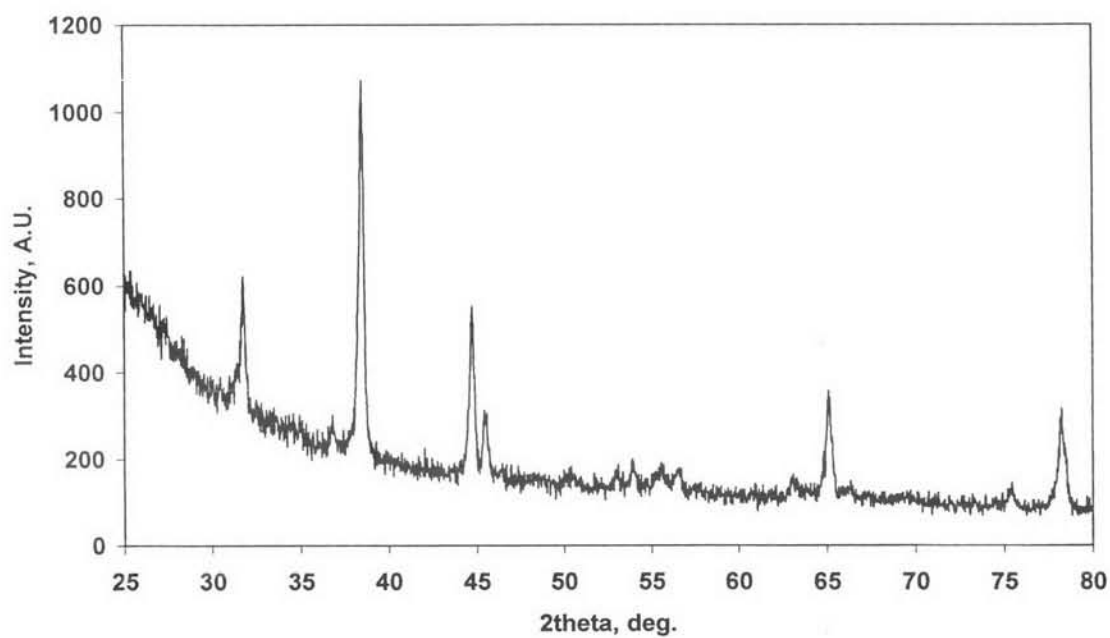


Fig. C14 XRD patterns of 0.1mol% $HfCl_2$ TPP added after mixed 4mol% $HfCl_4$ - $NaAlH_4$ after desorption.

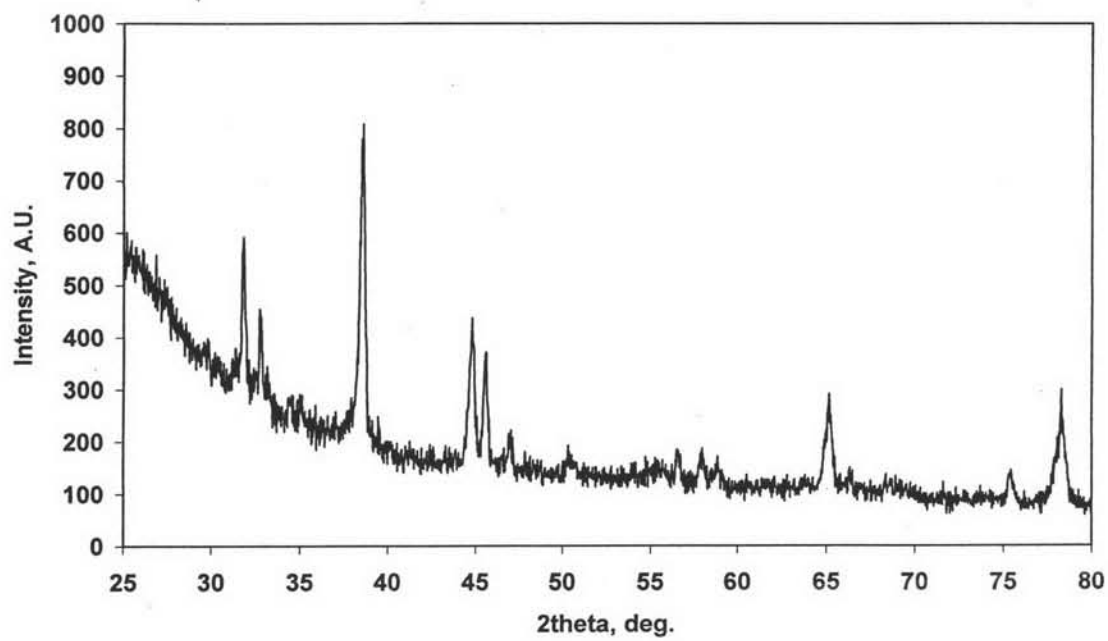


Fig. C14 XRD patterns of 0.1mol% HfCl_2TPP added after mixed 4mol% $\text{HfCl}_4\text{-NaAlH}_4$ after adsorption.

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