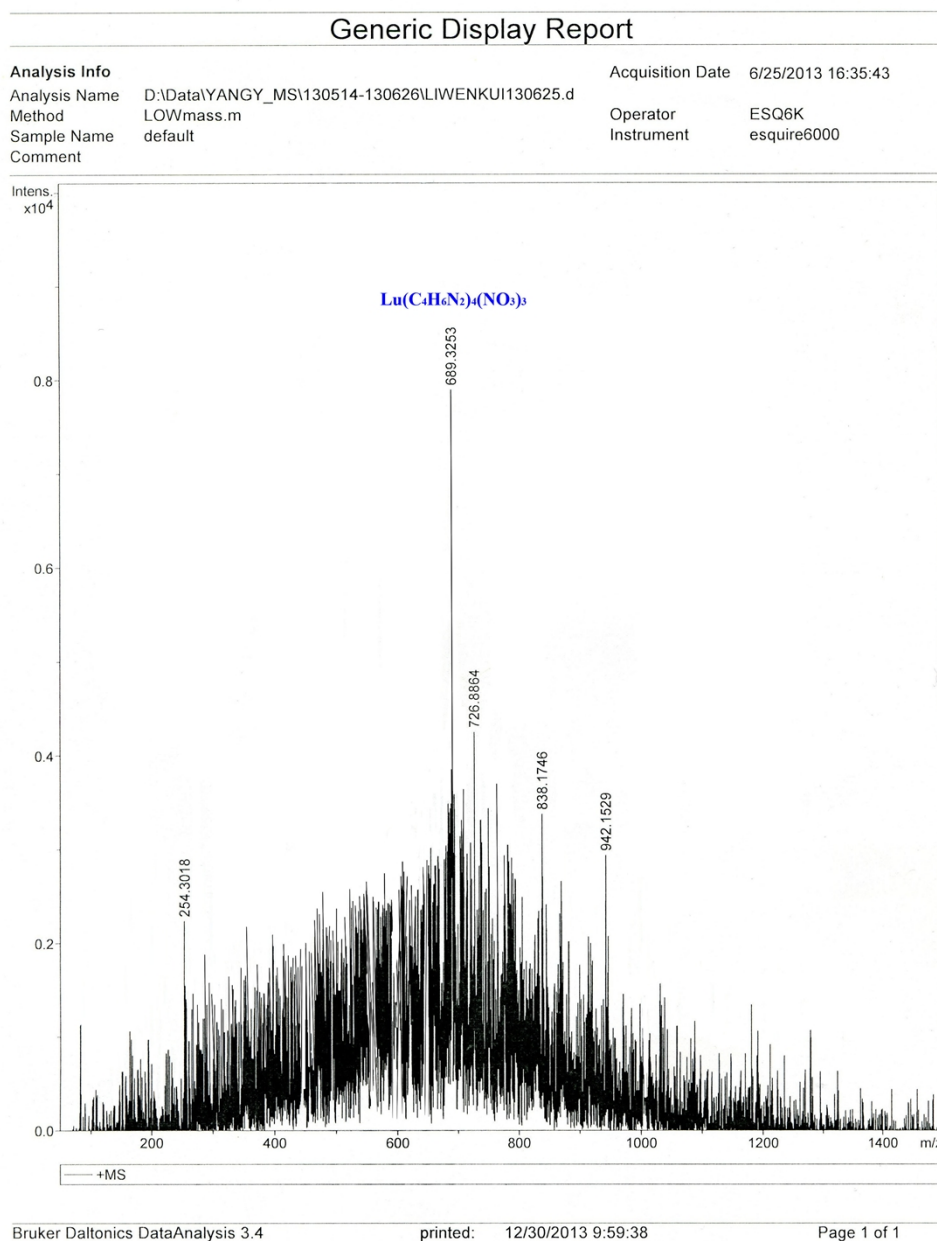


Supporting information

Figure 1 The photo of the solid in the IL phase after extraction.

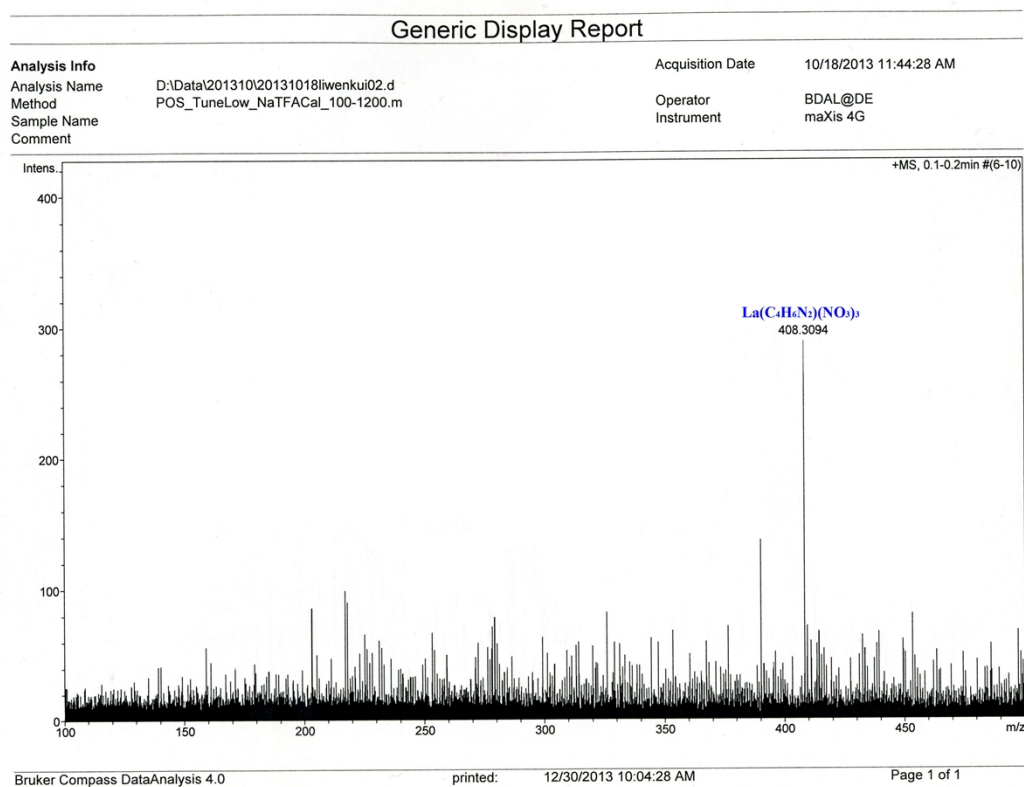


Figure 2 The ESI spectrum of the solid isolated from the [C₄mim][NTf₂] after extraction Lu³⁺ by washing the IL with ethyl acetate.



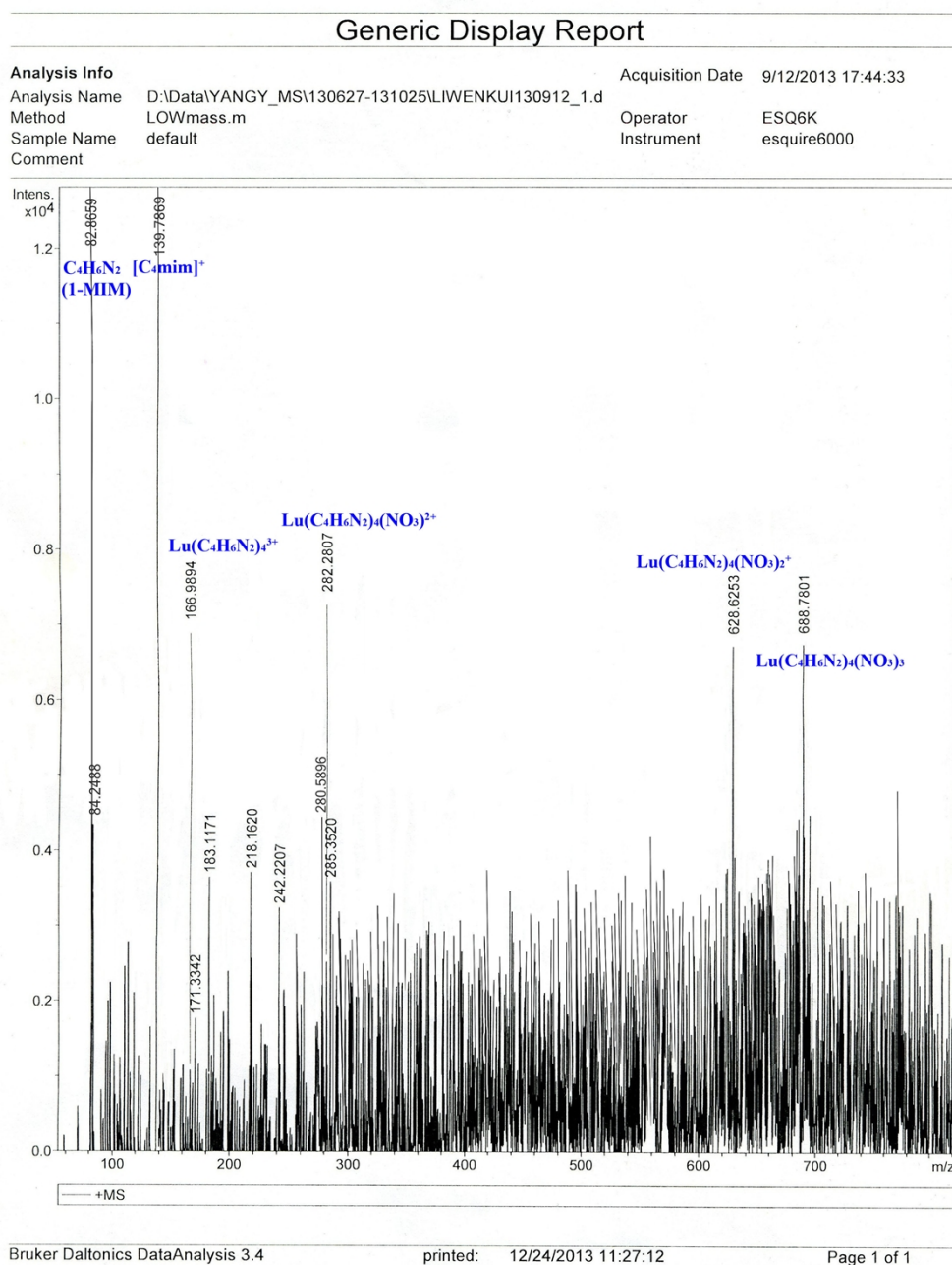
The peak at m/z 689.3253 can be found and it corresponds to the Lu(C₄H₆N₂)₄(NO₃)₃ (calcd. 689.3533).

Figure 3 The ESI spectrum of the solid isolated from the [C₄mim][NTf₂] after extraction La³⁺ by washing the IL with ethyl acetate.



The peak at m/z 408.3094 can be found and it corresponds to the La(C₄H₆N₂)(NO₃)₃ . (calcd. 407.0054).

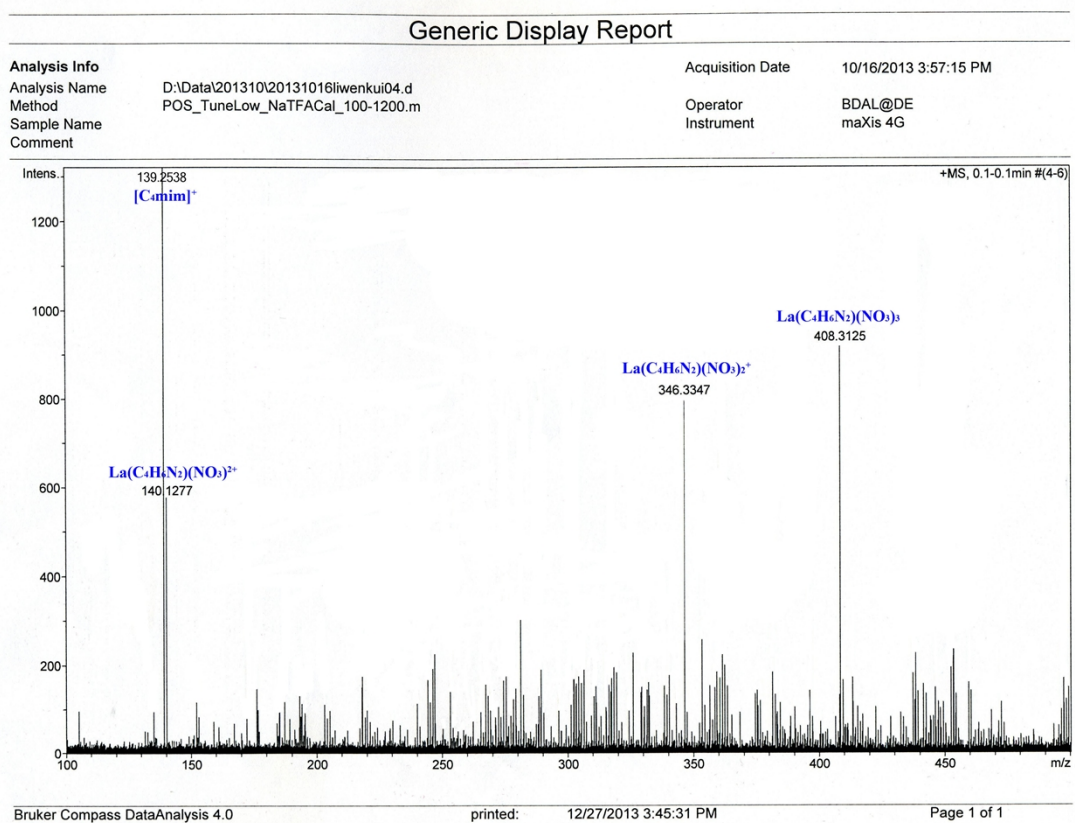
Figure 4 The ESI spectrum of the loaded $[C_4mim][NTf_2]$ phase after extraction of Lu^{3+} in methanol.



The peaks at m/z 82.8659, 139.7869 can be found and they correspond to the 1-MIM($C_4H_6N_2$, calcd. 82.0978), C_4mim^+ (calcd. 139.2121).

The peaks at m/z 688.7801, 628.6253, 282.2807, 166.9894 can be found and they correspond to the complex of $Lu(C_4H_6N_2)_4(NO_3)_3$, $Lu(C_4H_6N_2)_4(NO_3)_2^+$, $Lu(C_4H_6N_2)_4(NO_3)_2^{2+}$ and $Lu(C_4H_6N_2)_4^{3+}$.

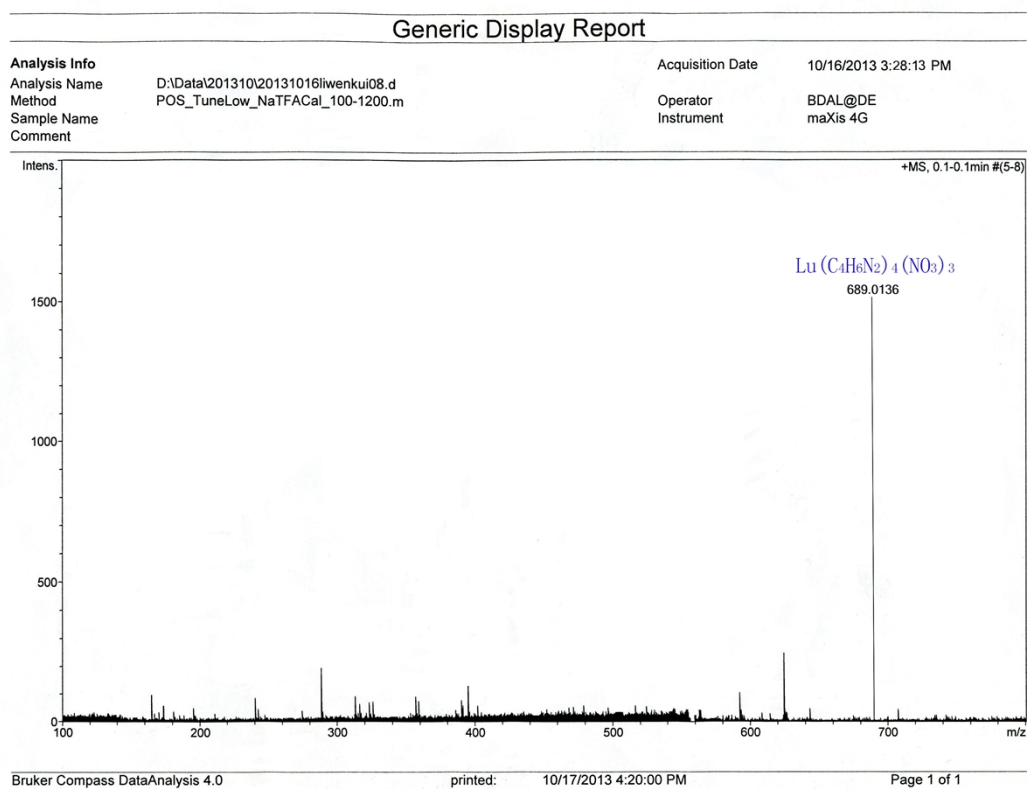
Figure 5 The ESI spectrum of the loaded $[C_4mim][NTf_2]$ phase after extraction of La^{3+} in methanol.



The peak at m/z 139.2538 can be found and it corresponds to the C_4mim^+ (calcd. 139.2121).

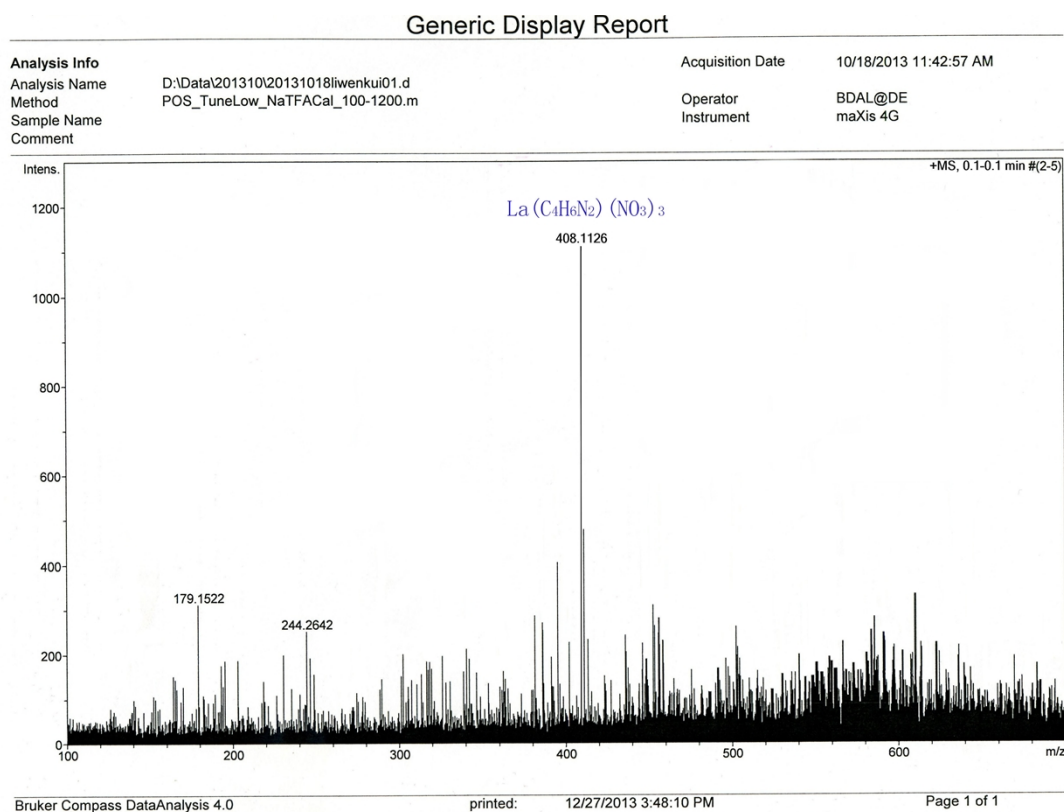
The peaks at m/z 408.3125, 346.3347, 140.1227 can be found and they correspond to the complex of $La(C_4H_6N_2)(NO_3)_3$, $La(C_4H_6N_2)(NO_3)_2^+$ and $La(C_4H_6N_2)(NO_3)^{2+}$.

Figure 6 The ESI spectrum of the loaded *n*-pentanol phase after extraction of Lu³⁺.



The peak at m/z 689.0136 can be found and it corresponds to the $\text{Lu}(\text{C}_4\text{H}_6\text{N}_2)_4(\text{NO}_3)_3$ (calcd. 689.3533).

Figure 7 The ESI spectrum of the loaded *n*-pentanol phase after extraction of La^{3+} .



The peak at m/z 408.1126 can be found and it corresponds to the $\text{La}(\text{C}_4\text{H}_6\text{N}_2)(\text{NO}_3)_3$ (calcd. 407.0054).