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Supplementary Information

The Knoevenagel condensation catalysed by ionic liquids: a mass spectrometric insight into the reaction mechanism

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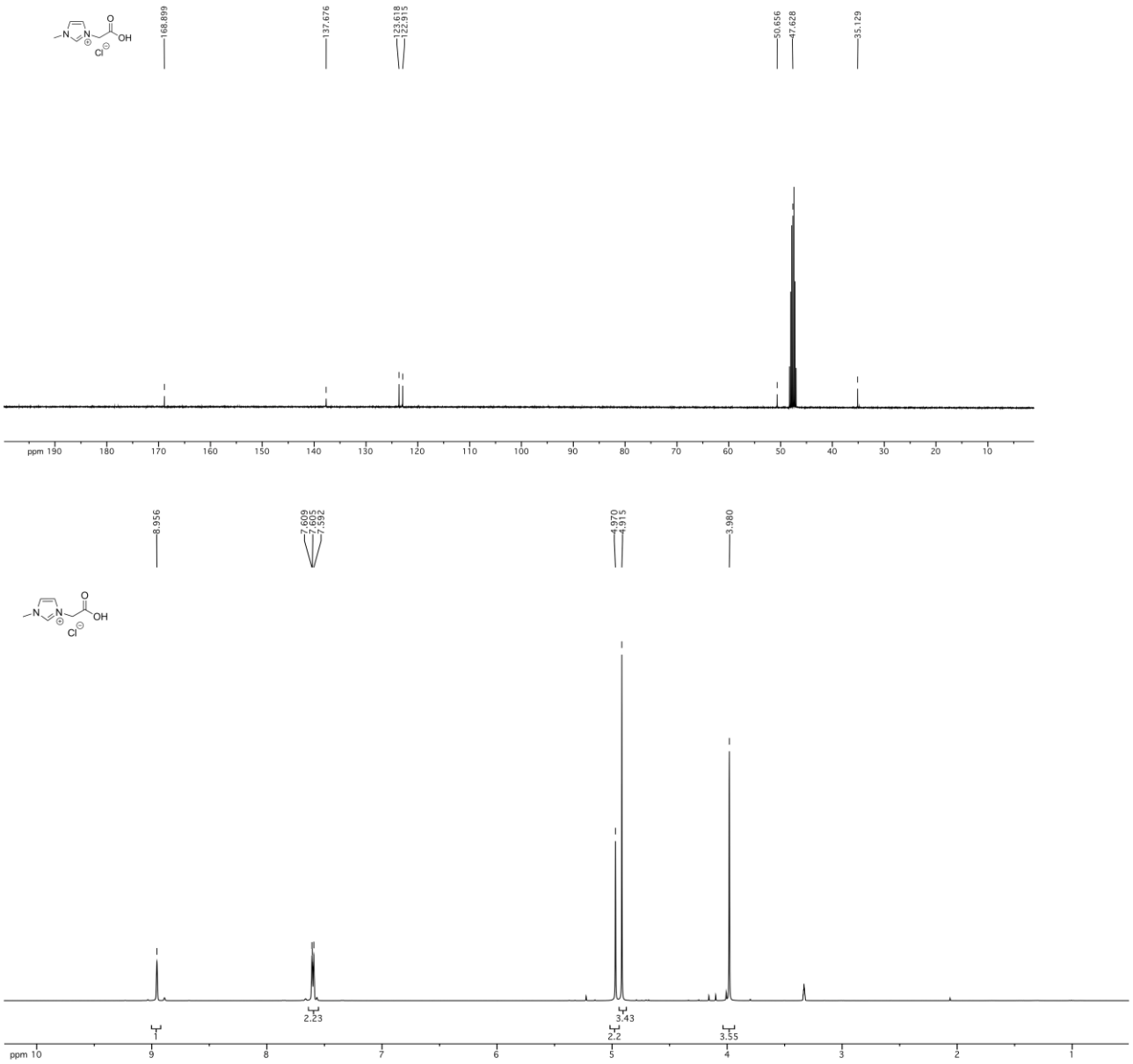
Table of Content:

Synthesis of 1-methyl-3-carboxymethylimidazolium chloride (MAICl)

The acidic ionic liquid 1-methyl-3-carboxymethylimidazolium chloride (MAICl) was synthesized according to the literature procedure. [1]

MAICl: White solid mp 205 °C, (80%) ^{1}H NMR (400 MHz, CD_3OD): δ = 8.96 (s, 1 H), 7.61 (s, 1 H), 7.59 (s, 1 H), 4.97 (s, 2 H) 3.98 (s, 3 H).^{13}C NMR (101 MHz, CD_3OD): δ =168.9, 137.7, 123.6, 122.9, 55.59, 35.1.



General procedure for the Knoevenagel condensation

A mixture of carbonyl compound (1.0 mmol), activated methylene compound (1.0 mmol) and catalyst (10 mol %) was stirred at room temperature in a 5-mL vial. Upon completion of the reaction (monitored by TLC), the reaction mixture always solidified in the vial. The solidified mixture was then washed with cold water (5 mL) to remove the catalyst, and evaporated under reduced pressure to obtain the target products. All products were prepared under solvent-free condition. This procedure is followed for condensations of all substrates listed in Table 2. All the products are known compounds and were identified by comparison of their spectroscopic data with those reported.

Ethyl(*E*)-2-cyano-3-(4-methoxyphenyl)-2-propenoate (3a): [2] Yellow crystalline solid, mp 79-81 °C, (91%). ^{1}H NMR (200 MHz, $CDCl_3$): δ = 8.16 (s, 1 H), 7.99 (d, *J* = 9.0 Hz, 2 H), 6.98 (d, *J* = 8.8 Hz, 2 H), 4.36 (q, *J* = 7.0 Hz, 2 H), 3.89 (s, 3 H), 1.38 (t, *J* = 7.0 Hz, 3 H). ^{13}C NMR (50.3 MHz, $CDCl_3$): δ =163.72, 162.93, 154.19, 133.55, 124.22, 116.15, 114.70, 99.17, 62.32, 55.59, 14.15.

2-(4-Methoxybenzylidene)malononitrile (3b): [3] White solid, mp 114-115 °C, (97%). ^{1}H NMR (200 Hz, $CDCl_3$): δ = 7.92 (d, *J* = 9.0 Hz, 2H), 7.66 (s, 1H), 7.02 (d, *J* = 9.0 Hz, 2H), 3.92 (s, 3H). ^{13}C NMR (50.3 MHz, $CDCl_3$): δ = 164.88, 159.99, 133.48, 124.02, 115.17, 114.51, 113.44, 78.29, 55.85.

[1] Z. Fei, D. Zhao, T.J.Geldbach, R.Scopelliti, P.J. Dyson *Chem. Eur. J* **2004**,*10*, 4886-4893.

[2] J. S. Yadav, B. V. Subba Reddy, A. K. Basak, B. Visali, A. V. Narsaiah, K. Nagaiah, *Eur. J. Org. Chem.* **2004**, 546-551.

[3] H. Xu, L. Pan, X. Fang, B. Liu, W. Zhang, M. Lu, Y. Xu, T. Ding, H. Chang, *Tetrahedron Letters* **2017,** *58*, 2360-2365.

Figures

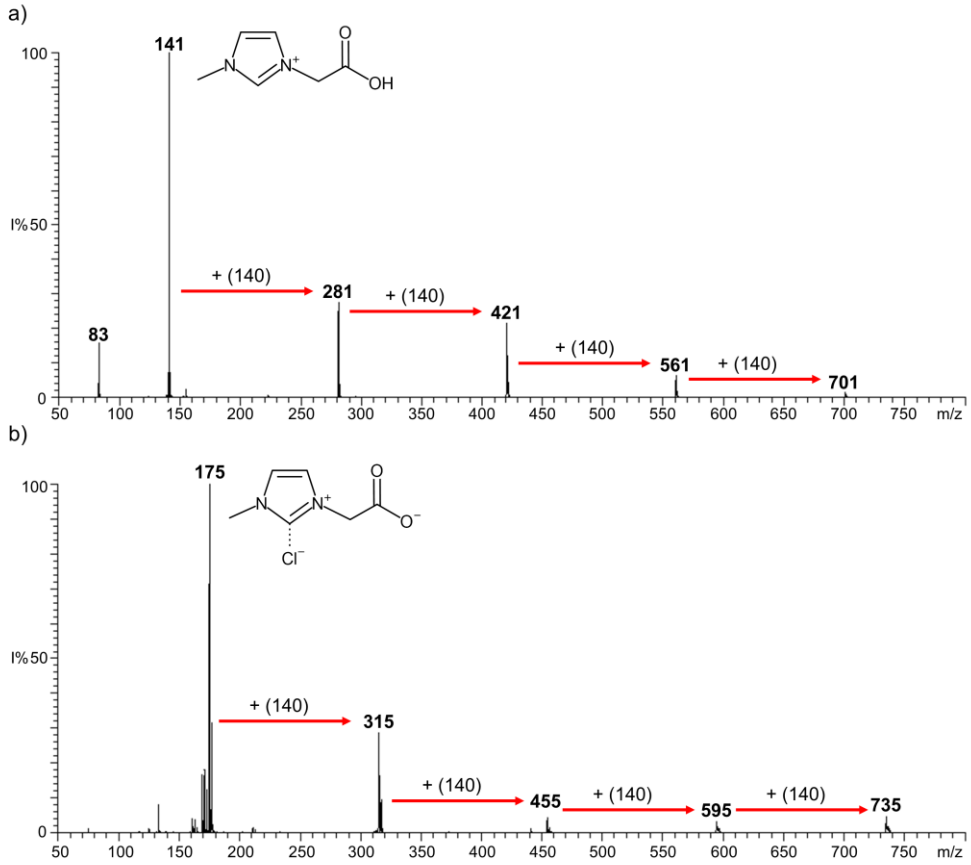


Figure S1. a) ESI-(+) and b) ESI-(-)-MS of a 10^{-3} M solution of MAICl ionic liquid in H_2O/CH_3CN (1:7 V/V) showing adducts with the zwitterion (140 Da).

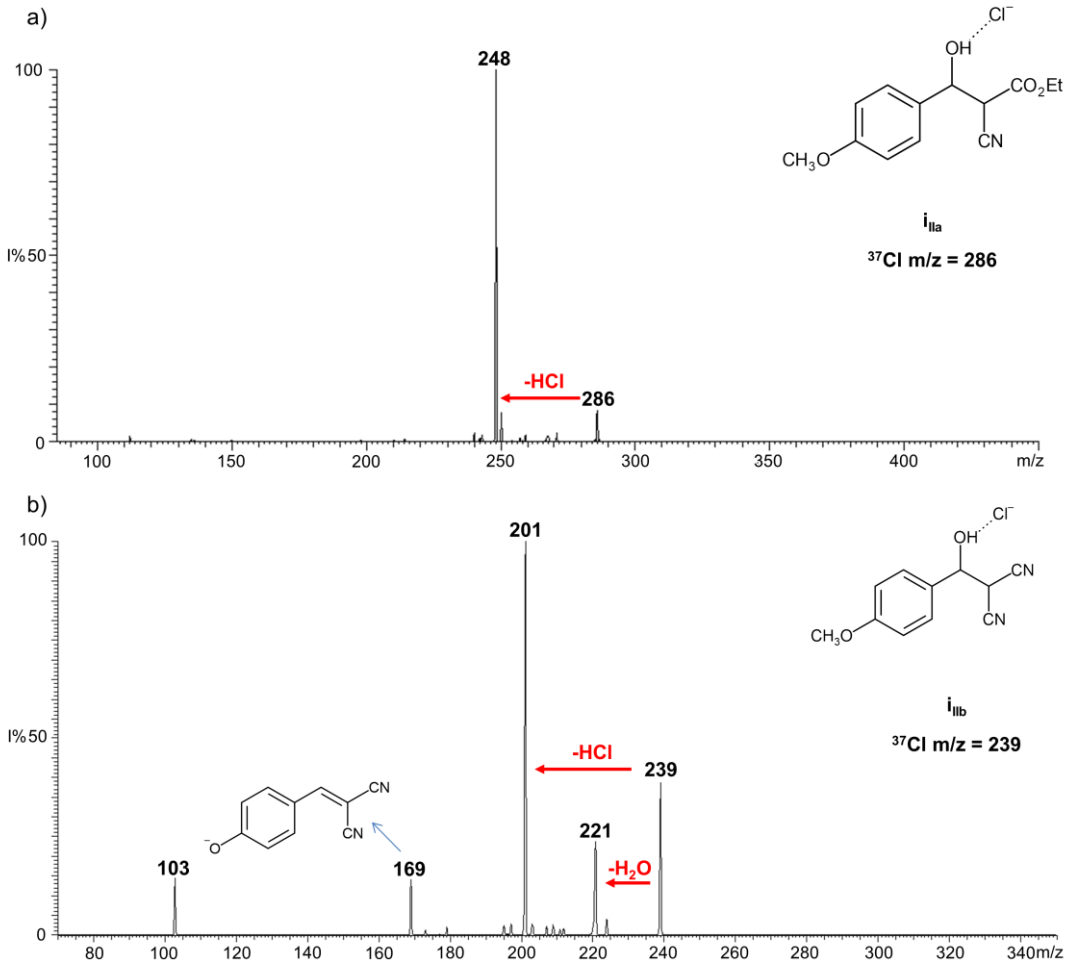


Figure S2. ESI-(-) CID mass spectra of the two ^{37}Cl isotope-containing intermediates a) i_{IIa} at *m/z* 286 and b) i_{IIb} at *m/z* 239 respectively isolated from a 1:1 *p*-anisaldehyde/**2a** and a 1:1 *p*-anisaldehyde/**2b** reaction mixture in the presence of 10% BMImCl catalyst.

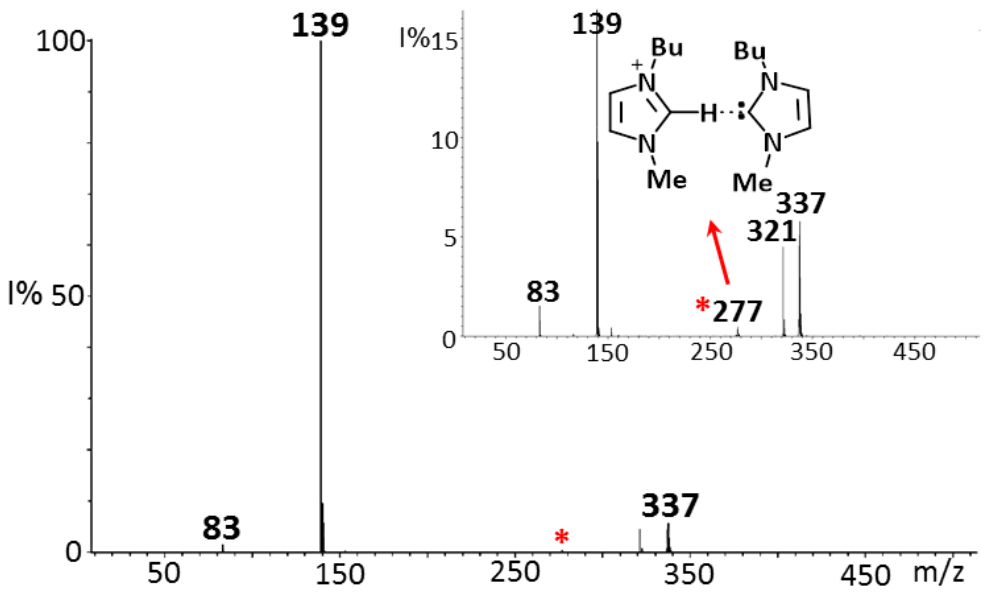


Figure S3. ESI-(+) mass spectrum of a 10^{-4} M solution of BMImAc dissolved in CH_3CN. In the inset is reported the y-axis magnification of the spectrum.

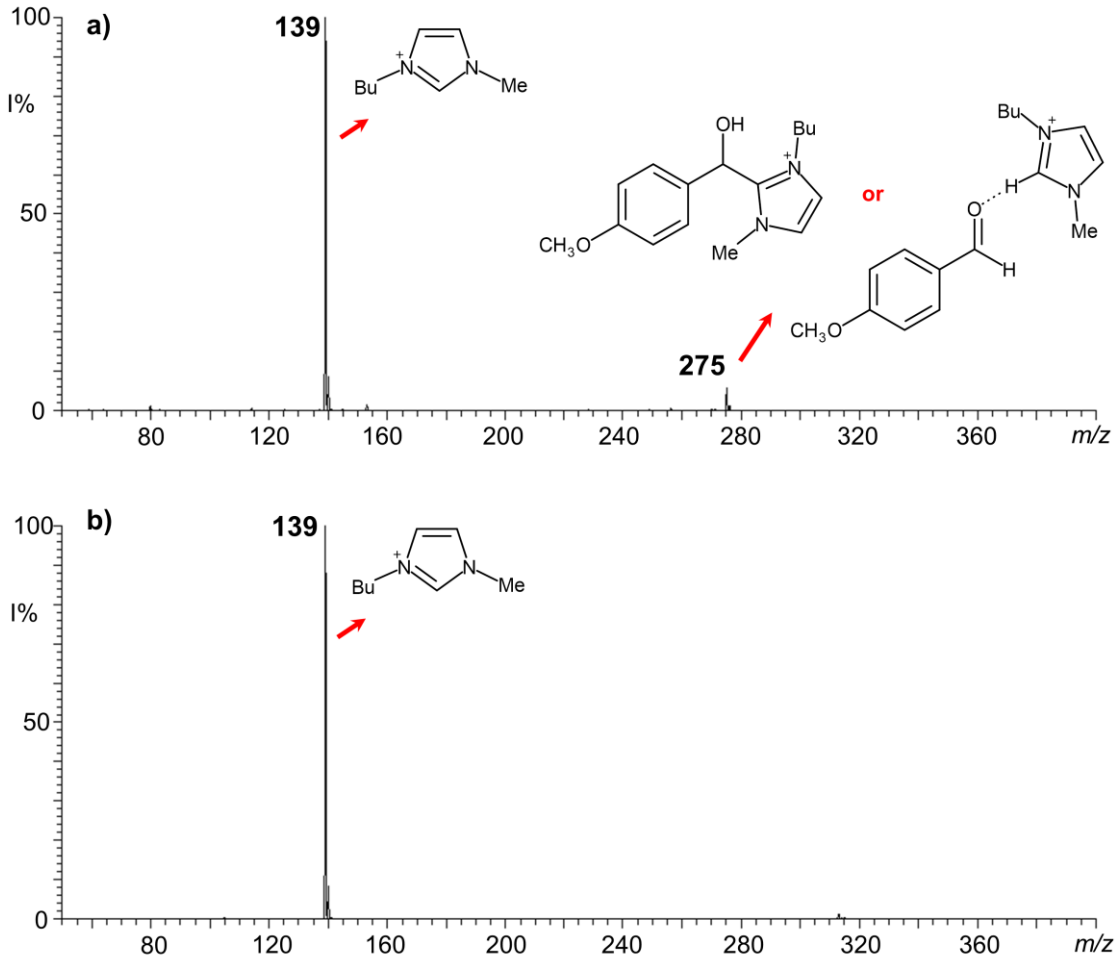
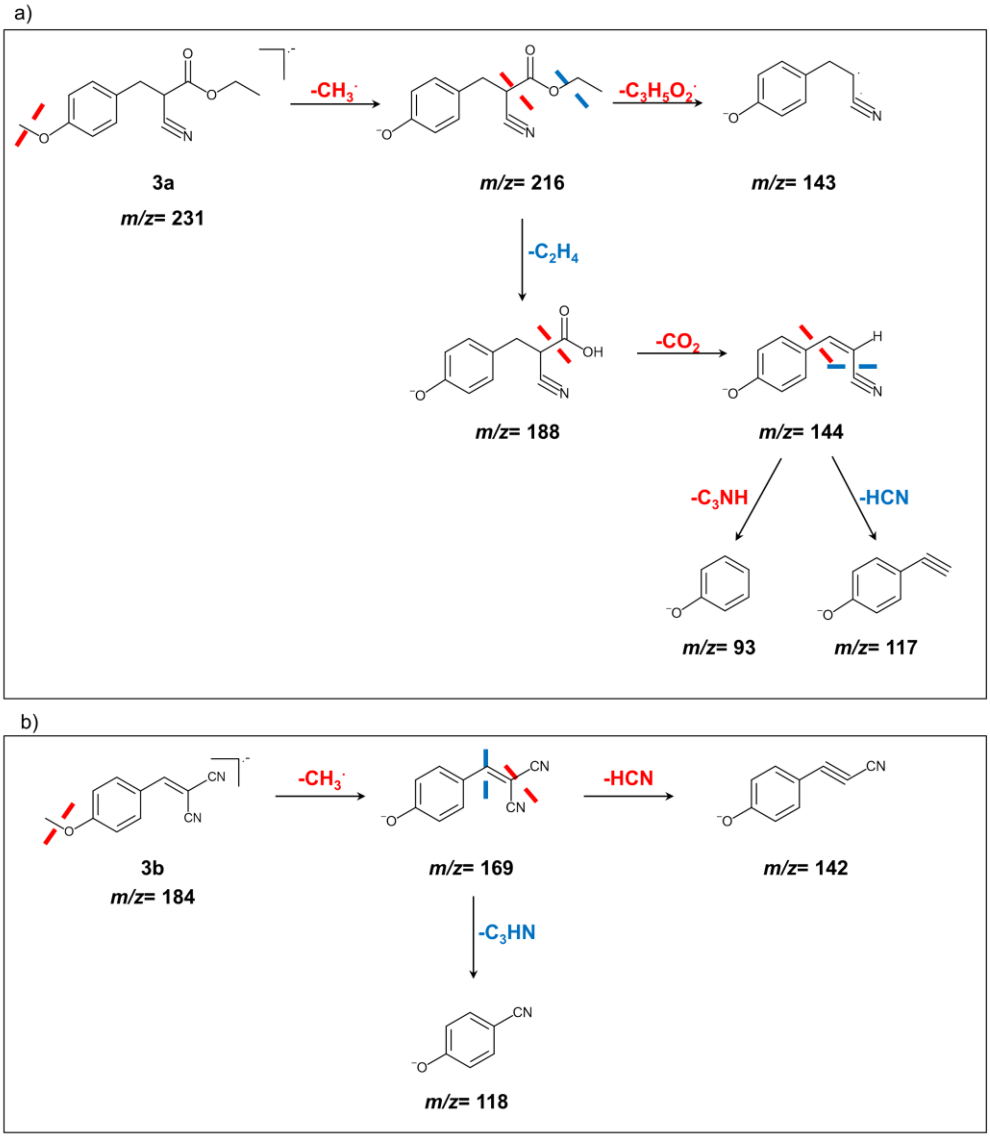
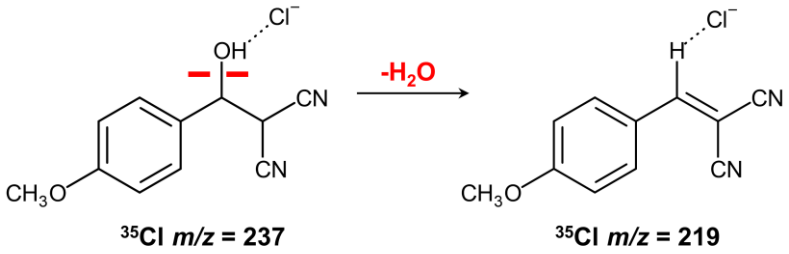


Figure S4. ESI-(+) mass spectrum of a 1:1 *p*-anisaldehyde/**2a** reaction mixture in the presence of a) BMImAc and b) BMImCl catalysts.

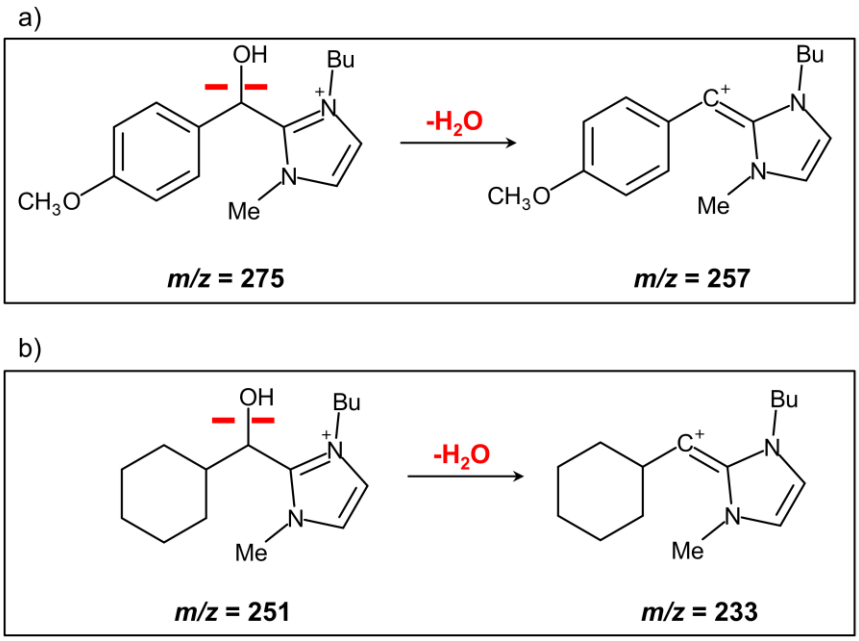
Schemes



Scheme S1. IT-MS fragmentation pattern of the Knoevenagel product radical anions at a) *m/z* 231 and b) *m/z* 184.



Scheme S2. Dehydration pattern of the ^{35}Cl-containing intermediate **i$_{IIb}$** at *m/z* 237 suggested by IT-MS fragmentation experiments.



Scheme S3. Dehydration pattern of the *p*-anisaldehyde-carbene intermediate at a) *m/z* 275 and b) *m/z* 251 suggested by IT-MS fragmentation experiments.