

1 Supplementary Information: **High-Performance Particulate Matter**
2 **Including Nanoscale Particle Removal by a Self-powered Air Filter**

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14 **This PDF file includes:**

15 Supplementary Tables 1

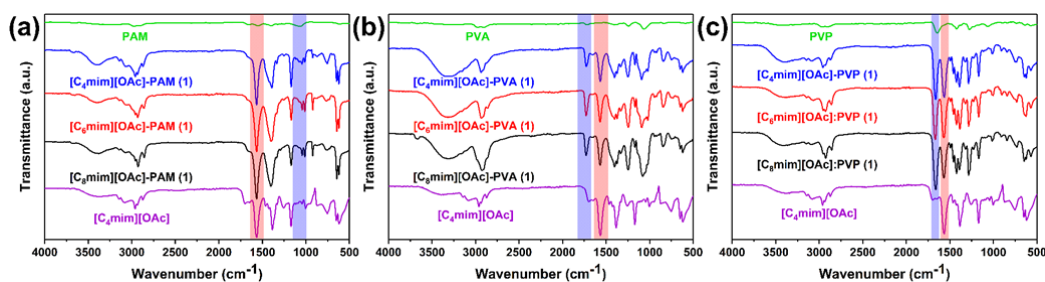
16 Supplementary Figures 1 to 17

17 Supplementary References

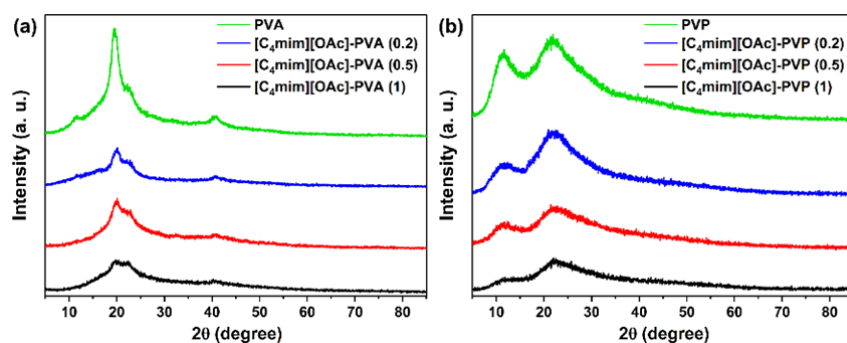
18

19 Supplementary **Table 1 | Water, CH₂I₂ contact angle and surface free energy (γ^{tot})**
20 **of the ILP composites with different polymers (PAM, PVA and PVP) and**
21 **amounts of ILs.** The γ^{tot} values were calculated by Owens two-zone mechanism of
22 adhesion¹.

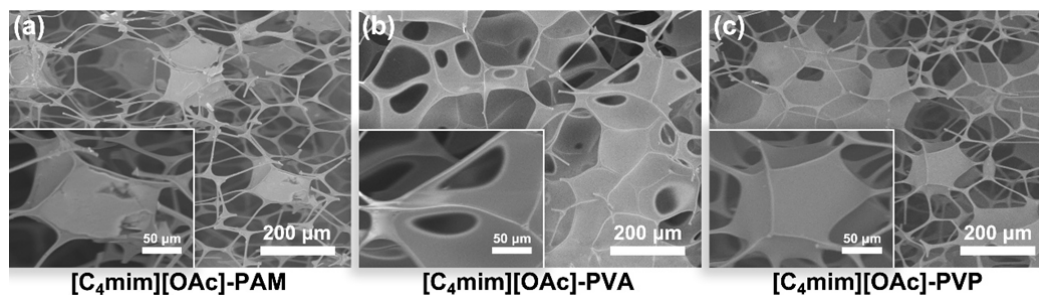
Film material	Water contact angle (°)	CH ₂ I ₂ contact angle (°)	Polar surface energy γ^{p} (mN m ⁻¹)	Dispersive surface energy γ^{d} (mN m ⁻¹)	Total surface free energy γ^{tot} (mN m ⁻¹)
PAM	72.0	69.4	16.5	16.2	32.6
PVA	82.3	63.3	22.0	7.3	29.4
PVP	81.4	40.1	36.2	3.7	39.9
[C ₄ mim][OAc]-PAM (0.2)	55.4	64.3	16.5	28.4	45.0
[C ₄ mim][OAc]-PAM (0.5)	51.2	69.4	13.3	34.9	48.2
[C ₄ mim][OAc]-PAM (1)	48.4	59.9	17.9	32.6	50.5
[C ₄ mim][OAc]-PVA (0.2)	89.0	49.6	32.4	2.1	34.6
[C ₄ mim][OAc]-PVA (0.5)	76.5	52.2	27.7	8.1	35.8
[C ₄ mim][OAc]-PVA (1)	64.9	57.1	22.3	17.4	39.7
[C ₄ mim][OAc]-PVP (0.2)	65.6	41.6	31.4	12.5	43.9
[C ₄ mim][OAc]-PVP (0.5)	50.9	45.1	26.5	24.5	50.9
[C ₄ mim][OAc]-PVP (1)	40.4	43.8	25.4	32.3	57.7



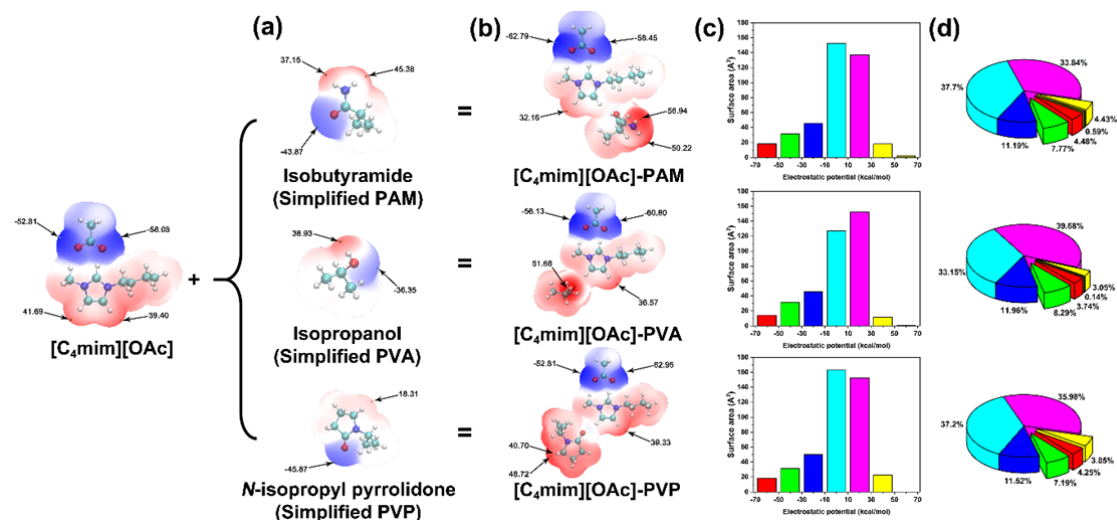
Supplementary Figure 1 | FTIR spectra of different ILP composites. (a) ILP composites with different ILs ([C₄mim][OAc], [C₆mim][OAc] and [C₈mim][OAc]) and PAM. (b) ILP composites with different ILs and PVA. (c) ILP composites with different ILs and PVP. Source data are provided as a Source Data file.



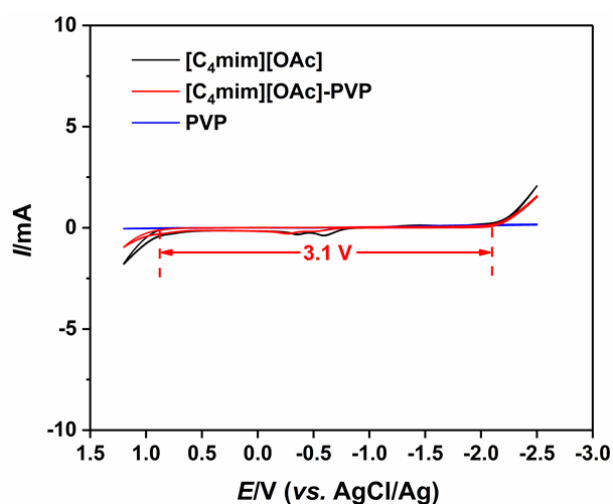
Supplementary Figure 2 | PXRD patterns of different ILP composites. (a) The ILP composites consisting of [C₄mim][OAc] and PVA. (b) The ILP composites consisting of [C₄mim][OAc] and PVP. Source data are provided as a Source Data file.



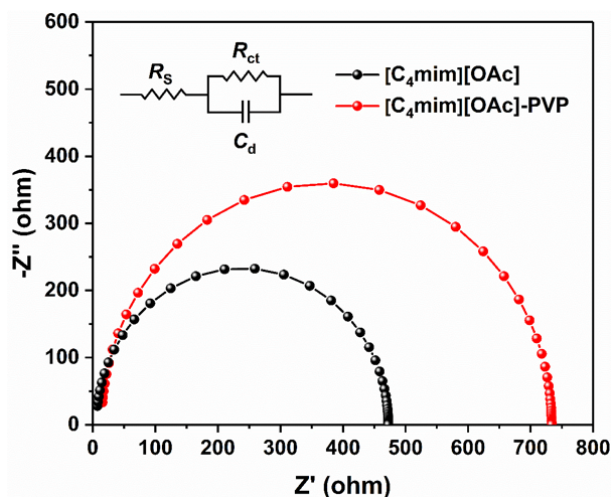
Supplementary Figure 3 | SEM images of ILP@MF filters with different species of polymers. (a) [C₄mim][OAc]-PAM. (b) [C₄mim][OAc]-PVA. (c) [C₄mim][OAc]-PVP.



Supplementary **Figure 4 | ESP-mapped molecular vdW surface of the [C₄mim][OAc].** (a) simplified polymers. (b) ILP composites consisting of [C₄mim][OAc] and different polymers. (c) Surface area in each ESP range on the vdW surface of the ILP composites. (d) Area percent in each ESP range on the vdW surface. Source data are provided as a Source Data file.



Supplementary **Figure 5 | Cyclic voltammograms of [C₄mim][OAc], PVP and [C₄mim][OAc]-PVP composite.** $T = 298\text{ K}$, $\nu = 0.1\text{ V s}^{-1}$. Source data are provided as a Source Data file.



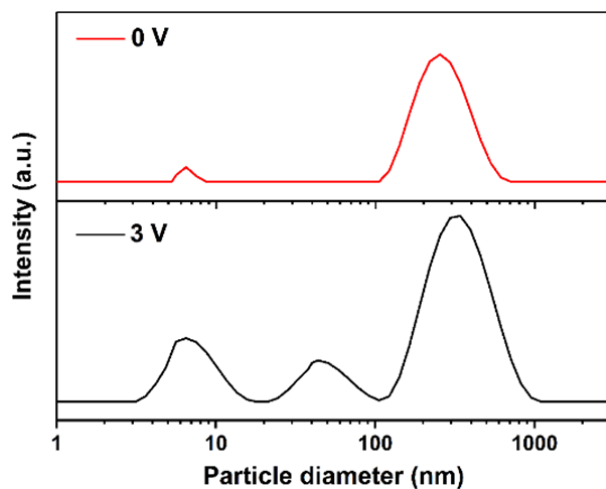
49

50 Supplementary **Figure 6 | The representative Nyquist plots of pure $[C_4mim][OAc]$**

51 **and $[C_4mim][OAc]$ -PVP composite.** The inset image is the equivalent circuit used

52 for fitting the Nyquist plots. Source data are provided as a Source Data file.

53



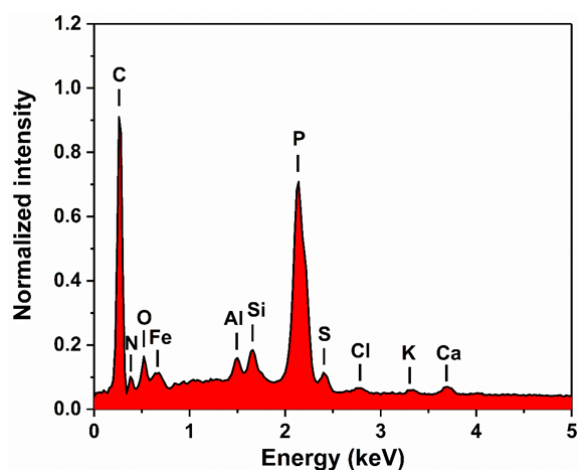
54

55 Supplementary **Figure 7 | DLS curves of the particles washed from the used**

56 **$[C_4mim][OAc]$ -PVP@MF filter under different voltage.** Source data are provided

57 as a Source Data file.

58

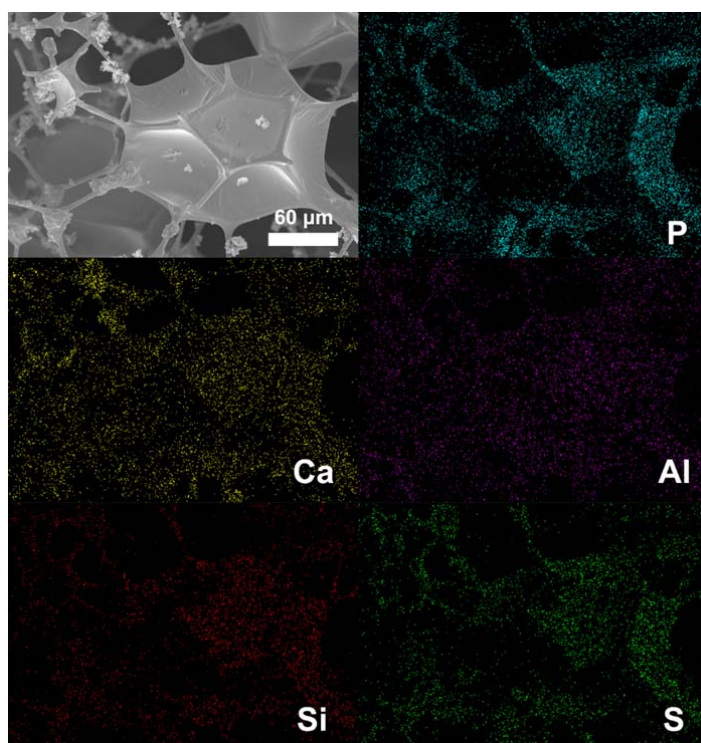


59

60 Supplementary Figure 8 | The EDS spectrum of the charged

61 $[C_4mim][OAc]$ -PVP@MF filter after the filtration test. Source data are provided as

62 a Source Data file.



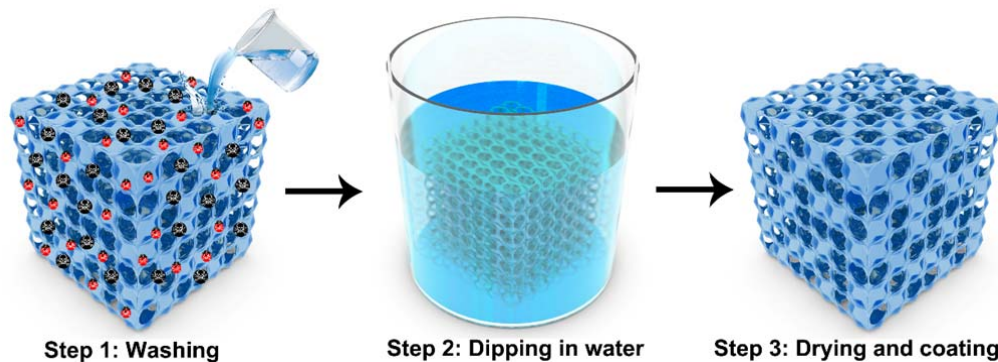
63

64 Supplementary Figure. 9 | EDS mapping images of the charged

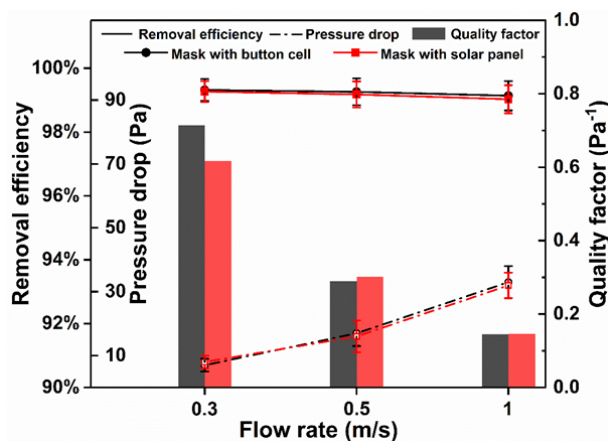
65 $[C_4mim][OAc]$ -PVP@MF filter after the filtration test. Phosphorus (P; blue dots),

66 calcium (Ca; yellow dots), aluminium (Al; purple dots), silicon (Si; red dots), and

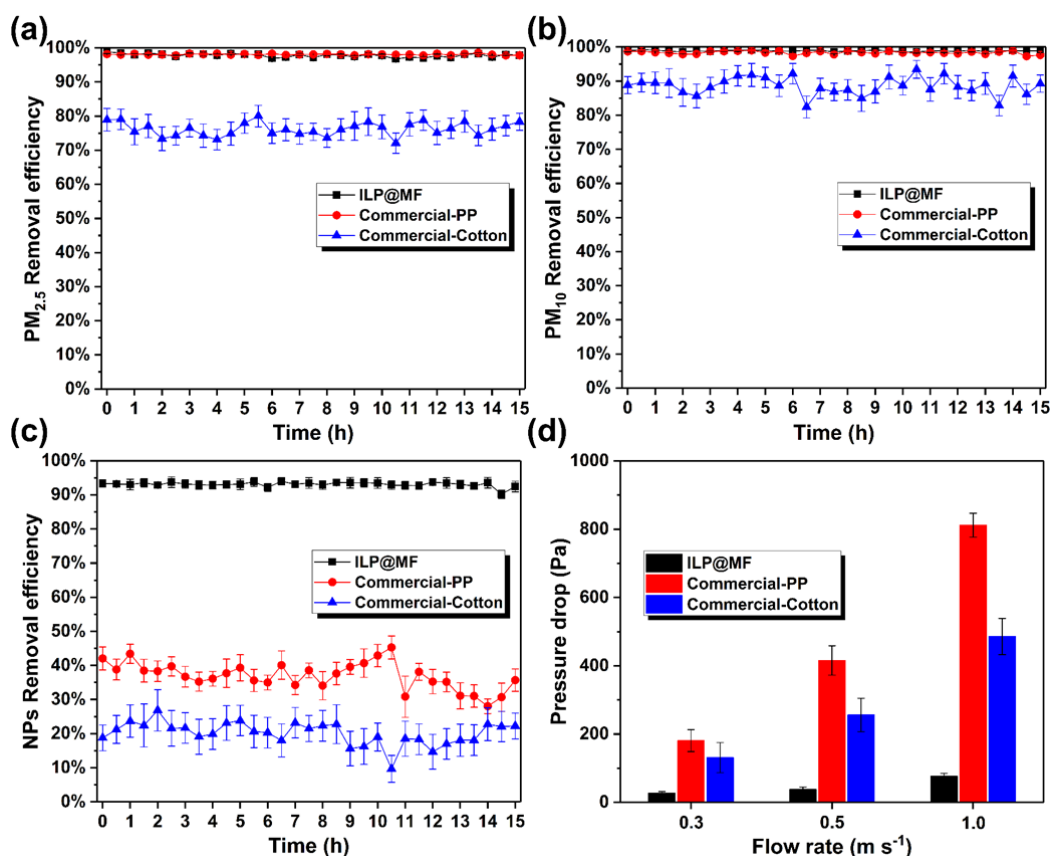
67 sulfur (S; green dots).



Supplementary **Figure 10** | Schematic illustration of the regeneration procedure for the dusty ILP@MF filter.

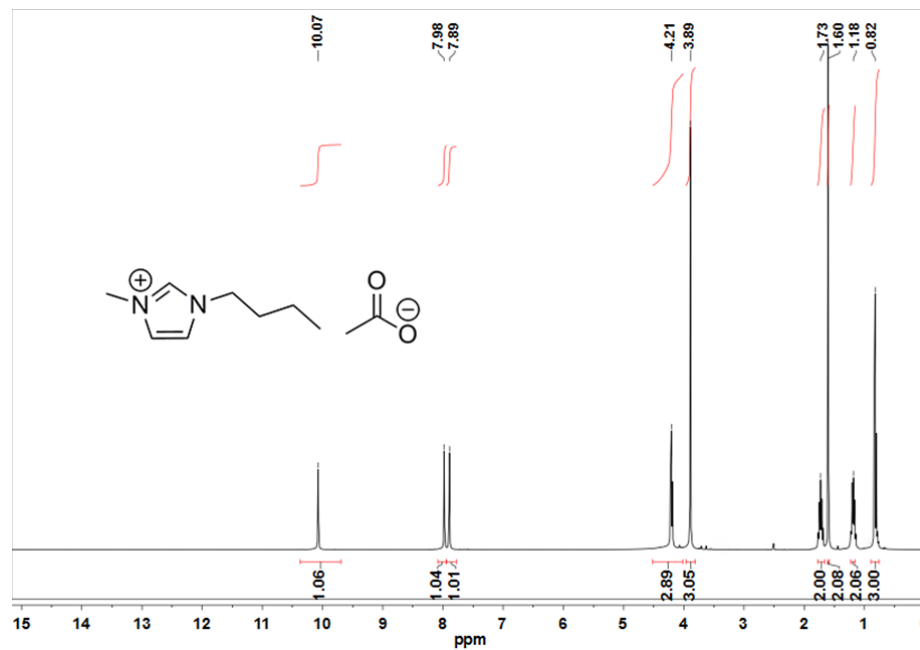


Supplementary **Figure 11** | Comprehensive index comparison including removal efficiency, pressure drop, and quality factor between masks made of button cell (black lines and pillars) and solar panel (red lines and pillars) under different flow rate. Error bar represents the standard deviation of three replicate measurements. Source data are provided as a Source Data file.



Supplementary **Figure 12 | Face masks filtration performance comparison** between ILP@MF, commercial-PP, and commercial-cotton filters. (a) removal efficiencies for PM_{2.5}. (b) removal efficiencies for PM₁₀. (c) removal efficiencies for NPs. (d) pressure drops in different flow rate conditions (0.3, 0.5, and 1 m s⁻¹). Error bar represents the standard deviation of three replicate measurements. Source data are provided as a Source Data file.

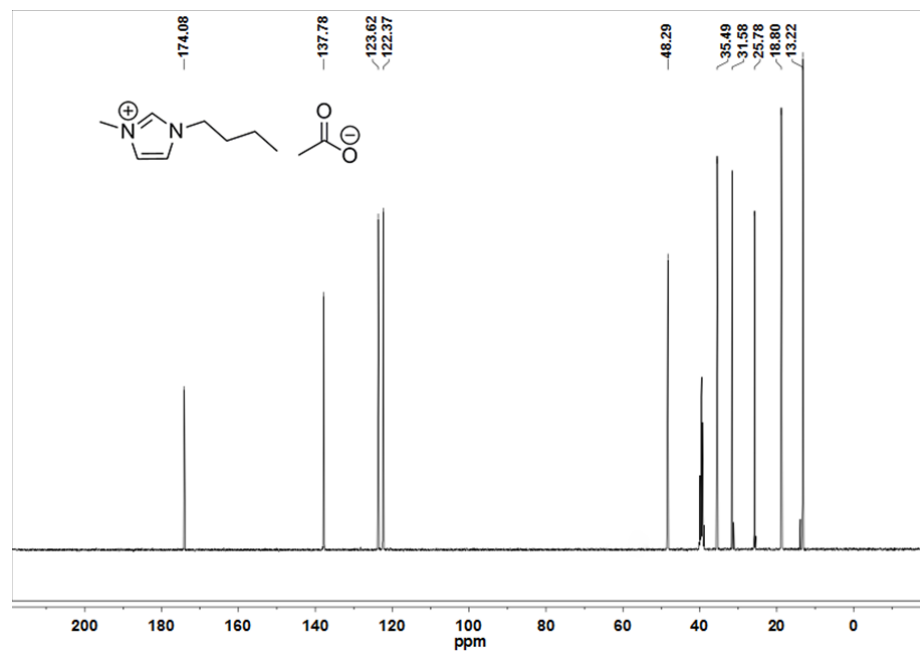
87 ^1H NMR (400 MHz, $\text{DMSO}-d_6$)



88

89

90 ^{13}C NMR (101 MHz, $\text{DMSO}-d_6$)

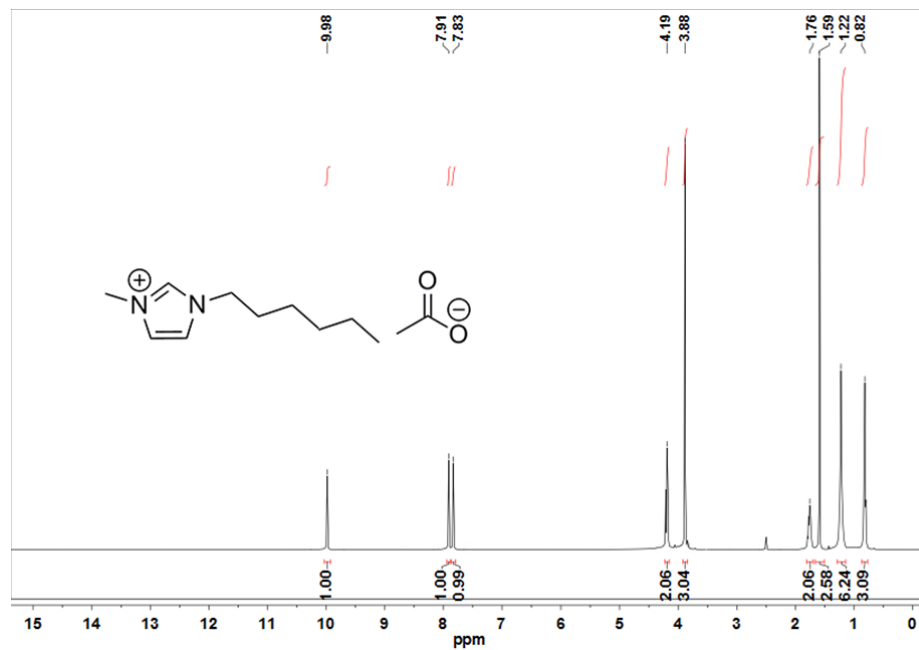


91

92 Supplementary **Figure 13** | ^1H and ^{13}C NMR spectra of $[\text{C}_4\text{mim}][\text{OAc}]$.

93

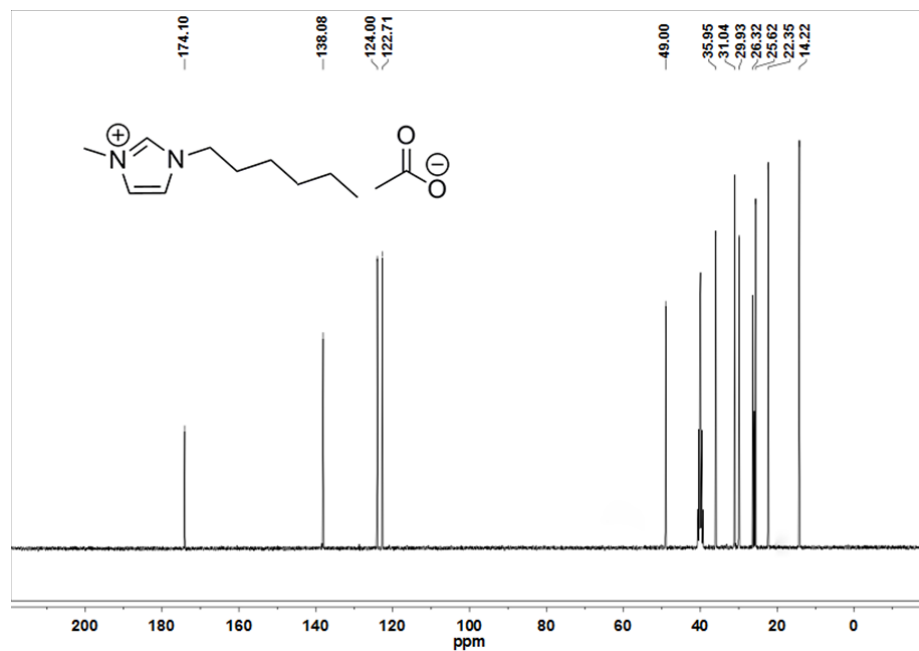
94 ^1H NMR (400 MHz, $\text{DMSO-}d_6$)



95

96

97 ^{13}C NMR (101 MHz, $\text{DMSO-}d_6$)

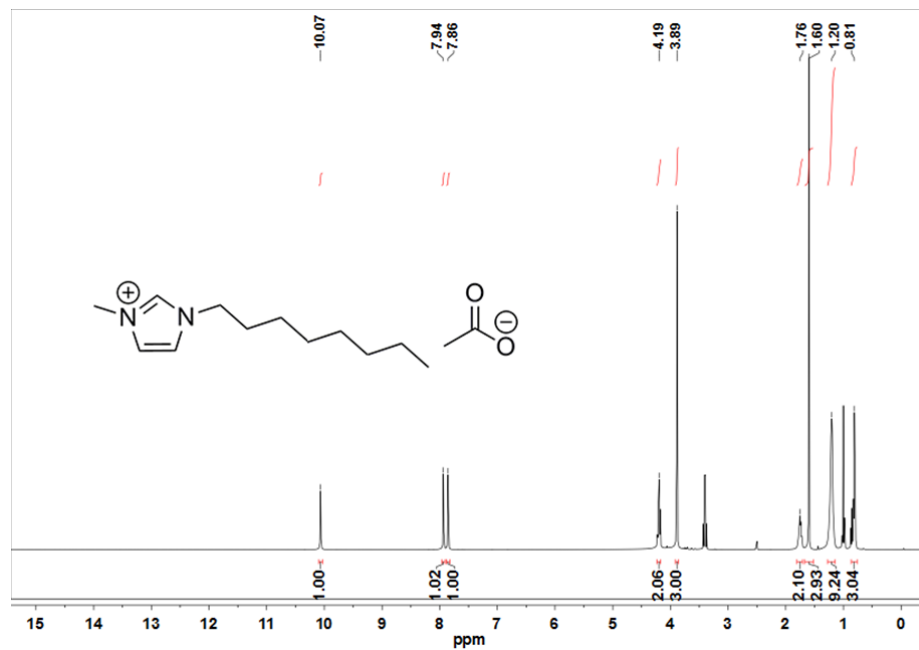


98

99 Supplementary **Figure 14** | ^1H and ^{13}C NMR spectra of $[\text{C}_6\text{mim}][\text{OAc}]$.

100

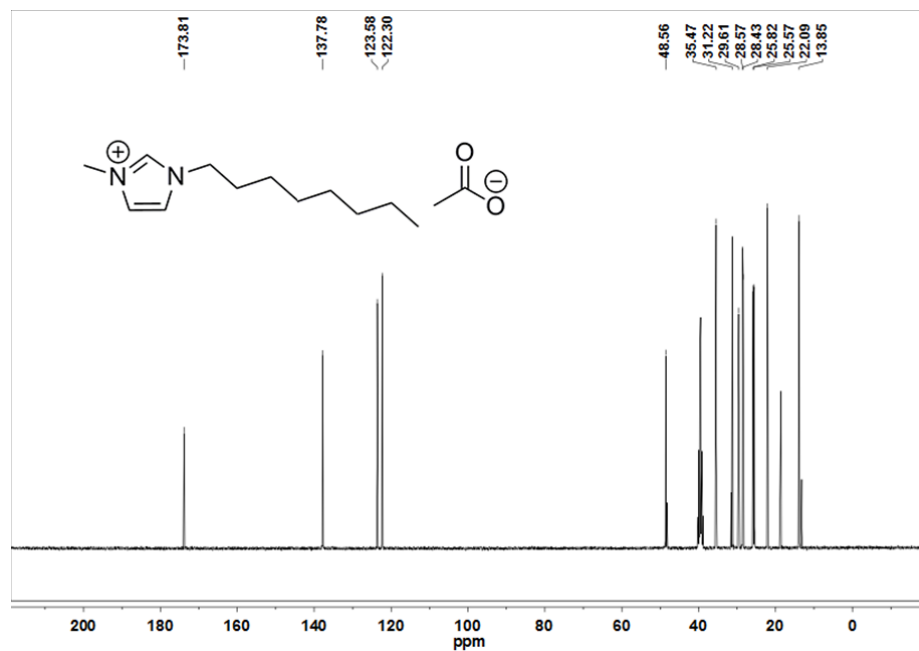
101 ^1H NMR (400 MHz, $\text{DMSO-}d_6$)



102

103

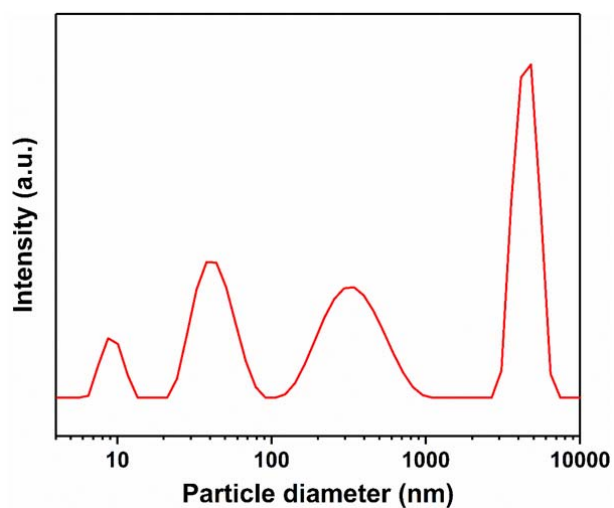
104 ^{13}C NMR (101 MHz, $\text{DMSO-}d_6$)



105

106 Supplementary **Figure 15** | ^1H and ^{13}C NMR spectra of $[\text{C}_8\text{mim}][\text{OAc}]$.

107

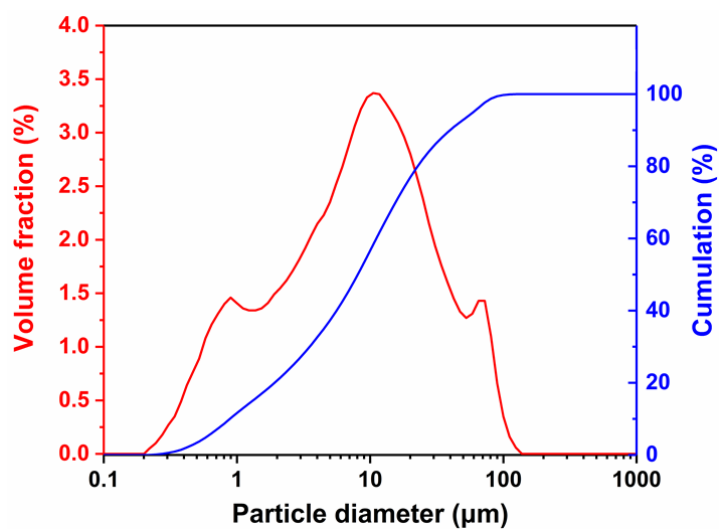


108

109 Supplementary **Figure 16 | DLS curves of the particles produced by the smoke of**

110 **burned cigarette.** Source data are provided as a Source Data file.

111



112

113 Supplementary **Figure 17 | Laser particle analysis curves of the particles**

114 **produced by the smoke of burned cigarette.** Source data are provided as a Source

115 Data file.

116

117 Supplementary **Table 2** | The optimized geometry coordinates (Å) of the three
 118 simplified polymers including isobutyramide (simplified PAM), isopropanol
 119 (simplified PVA), and *N*-isopropyl pyrrolidone (simplified PVP).

120

121 Isobutyramide

122

123	C	-1.36089300	-1.26989900	-0.02423200
124	C	-0.61606100	0.00079000	-0.46292500
125	C	-1.36031600	1.27039000	-0.02013800
126	C	0.79303500	-0.00044400	0.13774000
127	N	1.82296800	0.00153900	-0.76170300
128	O	0.98790500	-0.00293000	1.34117500
129	H	-2.37459900	-1.27591000	-0.43386600
130	H	-0.85054800	-2.17419000	-0.36697600
131	H	-1.42560800	-1.30960800	1.06517300
132	H	-0.53846000	0.00256700	-1.55682100
133	H	-0.84948500	2.17557300	-0.35979700
134	H	-2.37397600	1.27827500	-0.42985900
135	H	-1.42520500	1.30656200	1.06938300
136	H	2.76892800	0.00095200	-0.41179600
137	H	1.67034200	0.00342300	-1.75558300

138

139

140 Isopropanol

141

142	C	-1.32872100	-0.55399400	-0.08970300
143	C	-0.00218600	0.03731800	0.36373500
144	C	1.20042900	-0.78088500	-0.10316100

145	O	0.04498600	1.37356400	-0.16268800
146	H	-1.46092500	-1.56111600	0.31442700
147	H	-2.15891100	0.06850200	0.25054800
148	H	-1.36579300	-0.60826800	-1.18132600
149	H	0.00617200	0.08734000	1.46264100
150	H	2.14015100	-0.32531400	0.22664200
151	H	1.16460300	-1.79512900	0.30560300
152	H	1.21652900	-0.84544800	-1.19477500
153	H	0.88114900	1.77628800	0.09251400
154				
155				
156	<i>N</i> -isopropyl pyrrolidone			
157				
158	C	-2.04697300	-0.21087300	-1.28706900
159	C	-1.41878000	-0.62328800	0.05187900
160	C	-2.13521300	0.00803000	1.25201000
161	N	0.02965400	-0.34928600	0.08119600
162	C	0.57840200	0.90115300	-0.02171300
163	C	2.09257400	0.73871400	-0.15189700
164	C	2.35533100	-0.72657700	0.22307100
165	C	1.01196500	-1.42224700	-0.06936000
166	O	-0.03416400	1.95680400	-0.03381100
167	H	-1.53975100	-0.69793100	-2.12464700
168	H	-3.10021100	-0.50376900	-1.31410000
169	H	-1.98349700	0.86995700	-1.42262600
170	H	-1.49968500	-1.71103300	0.14575000
171	H	-1.68893900	-0.32963900	2.19099700
172	H	-3.18920700	-0.28380000	1.25030600
173	H	-2.07259200	1.09560300	1.20953700
174	H	2.35972900	0.95575900	-1.19185500

175	H	2.60797500	1.46645800	0.47518400
176	H	2.58221000	-0.80577200	1.28920400
177	H	3.18075400	-1.17898000	-0.32833300
178	H	0.98394100	-1.83803600	-1.08680100
179	H	0.80118000	-2.23771700	0.62797200

180

181

182

183 Supplementary **Table 3** | The optimized geometry coordinates (Å) of [C₄mim][OAc].

184

185 [C₄mim][OAc]

186

187	C	-0.22401600	3.08930100	0.13255200
188	C	0.95401300	2.55712500	-0.29116300
189	C	-0.54672200	0.91848500	-0.19882700
190	N	-1.14209200	2.05369200	0.18457900
191	H	-0.48461600	4.10076400	0.39288400
192	H	1.91045400	3.01836900	-0.46695000
193	H	-0.98466800	-0.12419200	-0.26892800
194	N	0.72903000	1.20603100	-0.49425200
195	C	-2.55468700	2.15158900	0.58371300
196	H	-2.61317800	2.56435200	1.59172700
197	H	-3.08167300	2.80386200	-0.11428300
198	H	-2.97385200	1.13862400	0.55793900
199	C	1.70986800	0.18896700	-0.91232100
200	H	2.26170300	0.59041500	-1.76631200
201	H	1.12894000	-0.67023700	-1.25143200
202	C	2.65628600	-0.21564200	0.21972800
203	H	2.05779000	-0.57925400	1.06151400

204	H	3.20887100	0.66248500	0.57517900
205	C	3.64191900	-1.30330200	-0.22247600
206	H	4.22758900	-0.94133900	-1.07642700
207	H	3.07828500	-2.17180600	-0.58042400
208	C	4.58910900	-1.73538700	0.90025400
209	H	4.03239900	-2.13382500	1.75344000
210	H	5.27524300	-2.51441800	0.55871500
211	H	5.19197700	-0.89498100	1.25835900
212	C	-2.54268100	-1.81722400	-0.03407900
213	O	-3.24496500	-0.86037600	0.36969000
214	O	-1.33538900	-1.72116100	-0.43086800
215	C	-3.15529400	-3.21855500	-0.06504300
216	H	-3.13748100	-3.60193600	-1.08921200
217	H	-2.54977500	-3.89717200	0.54222000
218	H	-4.18051300	-3.20762900	0.30510100

219

220

221 Supplementary **Table 4** | The optimized geometry coordinates (Å) of three ILP
222 composites including [C₄mim][OAc]-PAM, [C₄mim][OAc]-PVA and
223 [C₄mim][OAc]-PVP.

224

225 [C₄mim][OAc]-PAM

226

227	C	-0.56524500	-2.27806400	-1.23675400
228	C	0.19999900	-1.24538300	-0.79013400
229	C	-1.92371200	-0.80910700	-0.27698400
230	N	-1.88063800	-1.98751600	-0.90851500
231	H	-0.29160100	-3.18571800	-1.74657000
232	H	1.26350100	-1.06915200	-0.82168000

233	H	-2.82265600	-0.27316200	0.13814400
234	N	-0.66855800	-0.34582700	-0.19405700
235	C	-3.05899600	-2.82057100	-1.18649100
236	H	-3.17231300	-2.93540700	-2.26579500
237	H	-2.92306600	-3.79970500	-0.72451400
238	H	-3.93178800	-2.31311300	-0.75811000
239	C	-0.31692400	0.95574300	0.39813700
240	H	0.60180600	0.81608300	0.97104600
241	H	-1.12682700	1.21184100	1.08310300
242	C	-0.13763400	2.04685200	-0.65952900
243	H	-1.06492600	2.13464400	-1.23561100
244	H	0.65324000	1.74808100	-1.35646700
245	C	0.20892800	3.40046500	-0.02960500
246	H	1.12694400	3.30169900	0.56248800
247	H	-0.58299200	3.68461300	0.67229300
248	C	0.38828400	4.50904600	-1.07082000
249	H	-0.52635400	4.65377200	-1.65316800
250	H	0.63372000	5.46266800	-0.59600000
251	H	1.19366300	4.26833400	-1.77216800
252	C	-5.06220200	0.05575100	0.77059900
253	O	-5.19147800	-1.05656700	0.20458800
254	O	-3.97344200	0.70569500	0.87283000
255	C	-6.29756900	0.69992600	1.40702700
256	H	-6.15388800	0.76201600	2.49002100
257	H	-6.41412000	1.72278700	1.03908100
258	H	-7.19714000	0.12188000	1.19394000
259	C	4.51413100	-0.66078100	2.27190100
260	C	5.13216300	-0.83227600	0.87535400
261	C	5.09485500	-2.29993900	0.41805100
262	C	4.37967800	0.03632800	-0.13304200

263	N	5.12025200	0.97059300	-0.78897900
264	O	3.18039800	-0.09767300	-0.34523000
265	H	5.04471800	-1.28218000	2.99760600
266	H	4.56735500	0.37695400	2.61170200
267	H	3.46475000	-0.96252500	2.26158600
268	H	6.17754500	-0.50464400	0.91222200
269	H	5.55321400	-2.42836700	-0.56623500
270	H	5.63635200	-2.92947700	1.12856200
271	H	4.06283000	-2.65316400	0.36280700
272	H	4.66743000	1.56096600	-1.47039000
273	H	6.10483900	1.08994700	-0.62080800
274				
275				
276	[C ₄ mim][OAc]-PVA			
277				
278	C	1.26561200	0.64650900	0.03181400
279	C	0.36238500	1.58722500	0.42095300
280	C	-0.70838600	-0.35315200	0.25539700
281	N	0.57477200	-0.55151800	-0.06623300
282	H	2.32264500	0.72252500	-0.17716400
283	H	0.48522400	2.63880100	0.61480900
284	H	-1.55271800	-1.09817700	0.27771600
285	N	-0.85758800	0.94361700	0.55770900
286	C	1.13355800	-1.85592400	-0.45076500
287	H	1.59429900	-1.77048800	-1.43555500
288	H	1.88633600	-2.15415100	0.28022000
289	H	0.30717200	-2.57538200	-0.47099500
290	C	-2.15105500	1.54526800	0.92071000
291	H	-1.98636800	2.19014000	1.78810000
292	H	-2.79662900	0.71938100	1.22409300

293	C	-2.78381700	2.32375700	-0.23467200
294	H	-2.90857700	1.64566300	-1.08528900
295	H	-2.10672500	3.12322000	-0.55917900
296	C	-4.14110000	2.92074500	0.15451600
297	H	-4.01370500	3.58771300	1.01603800
298	H	-4.80526000	2.11421600	0.48421400
299	C	-4.80141600	3.68908500	-0.99346800
300	H	-4.97497200	3.03727300	-1.85467600
301	H	-5.76701100	4.10040300	-0.68863900
302	H	-4.17508400	4.52245600	-1.32709800
303	C	-2.67468600	-3.11856500	-0.00338300
304	O	-1.52606300	-3.47447200	-0.36023500
305	O	-2.99267400	-1.94699800	0.38017700
306	C	-3.80195600	-4.15456900	-0.01918500
307	H	-4.21226600	-4.26232500	0.98900000
308	H	-4.61484600	-3.80238000	-0.66048000
309	H	-3.44391900	-5.12097000	-0.37481500
310	C	5.38786400	0.42805700	1.37310200
311	C	5.71412300	0.72634000	-0.08220700
312	C	6.55928000	-0.36236700	-0.73748100
313	O	4.45033200	0.87710400	-0.76539300
314	H	6.30519100	0.35136900	1.96184400
315	H	4.77174000	1.22201100	1.80075000
316	H	4.84437000	-0.51711600	1.45802200
317	H	6.25252300	1.68245400	-0.13735700
318	H	6.76745900	-0.12462600	-1.78581600
319	H	7.52079700	-0.46483900	-0.22668000
320	H	6.04197600	-1.32496900	-0.69980600
321	H	4.62287500	1.03357500	-1.69996200

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326	C	-0.20787800	-0.73315700	-0.40461800
327	C	-1.17710100	-1.62933600	-0.73639500
328	C	-2.16987300	0.30883300	-0.29664800
329	N	-0.85175100	0.46457500	-0.13459000
330	H	0.86639100	-0.83111000	-0.34247900
331	H	-1.10639200	-2.66514100	-1.01987300
332	H	-2.98726400	1.06767800	-0.17635000
333	N	-2.38959000	-0.95991600	-0.66537700
334	C	-0.21692400	1.72863000	0.26510000
335	H	0.27692400	1.59234500	1.22799000
336	H	0.52273100	2.00762300	-0.48553100
337	H	-1.00561600	2.48506900	0.33584400
338	C	-3.73382200	-1.50853100	-0.90494100
339	H	-3.71185900	-2.04431300	-1.85789800
340	H	-4.39745200	-0.64839200	-1.01016500
341	C	-4.20790800	-2.42062700	0.22875400
342	H	-4.18449600	-1.85476000	1.16605000
343	H	-3.51234100	-3.26038200	0.34589700
344	C	-5.62387300	-2.95302100	-0.01911200
345	H	-5.64811600	-3.49818200	-0.97069400
346	H	-6.30992100	-2.10639300	-0.13131300
347	C	-6.11808600	-3.86724600	1.10549000
348	H	-6.13819200	-3.33855000	2.06304100
349	H	-7.12992600	-4.22842500	0.90470000
350	H	-5.46945100	-4.74129800	1.22116500
351	C	-4.02749400	3.13146500	0.11349100
352	O	-2.83104000	3.45888700	0.30108100

353	O	-4.43459400	1.95213100	-0.13710600
354	C	-5.10351300	4.22001200	0.17746900
355	H	-5.58023900	4.31504200	-0.80280700
356	H	-5.88289000	3.92873400	0.88682200
357	H	-4.67599500	5.18010100	0.46783500
358	C	4.45115500	1.92210500	1.32292500
359	C	5.18400500	1.39747700	0.08114100
360	C	4.60718000	1.95508400	-1.22525000
361	N	5.23712600	-0.07855500	0.06161700
362	C	4.14835600	-0.89341900	0.00207700
363	C	4.62198100	-2.33417500	0.17509500
364	C	6.14483500	-2.25877600	-0.00519100
365	C	6.47984700	-0.79838000	0.35095000
366	O	2.98424900	-0.53282800	-0.13999100
367	H	4.90322800	1.53261000	2.23909800
368	H	4.50704300	3.01323600	1.35699200
369	H	3.40024600	1.63046500	1.30282300
370	H	6.23025700	1.71105800	0.14739500
371	H	5.17642400	1.59526700	-2.08610700
372	H	4.65654100	3.04705200	-1.21634400
373	H	3.56666900	1.65428000	-1.34832200
374	H	4.33775900	-2.65798100	1.18240200
375	H	4.11528400	-2.99011800	-0.53331800
376	H	6.40825500	-2.44994400	-1.04823800
377	H	6.69384200	-2.96932000	0.61364500
378	H	6.75177200	-0.68848800	1.40955500
379	H	7.30205500	-0.39763800	-0.24725700

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381 **References**

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