# **Supplementary Information**

## The Reactivity of an Inorganic Glass Melt with ZIF-8

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#### 1. Powder X-ray Diffraction Measurements

In order to quantify the relative change in crystallinity across the *X* wt% ZIF-8 samples (Fig. 4 main paper) the .raw data were converted to .xy files using PowDLL (Fig. S4 and Fig S6-S9).<sup>1</sup> The background and broad inorganic first sharp diffraction peak (FSDP)<sup>2</sup> were fitted using a spline function and subtracted from the data. The three most intense peaks at approximately 7.3, 12.7 and 18.0 ° 2 $\theta$ , corresponding to {110}, {200} and {211} planes respectively, in ZIF-8 were then fitted. A Voigt function was used to fit the peaks at 12.7 and 18.0 ° 2 $\theta$ , whereas a split Voigt was used to fit the peak at 7.3 ° 2 $\theta$ . This is because the low angle peak displayed considerable asymmetry, which has been reported in the literature as occurring when using linear detectors at low angles in the Bragg–Brentano parafocussing geometry.<sup>3</sup> A relative measure of crystallinity was then obtained by dividing the these three areas by the corresponding area of the peak in the ball-milled evacuated ZIF-8 sample, the sample with the largest peak area, and then averaging (Table S2). The reported errors in the relative crystallinity values were obtained from standard deviation in the fractional areas of the three peaks. All peak fitting was done in Fityk.<sup>4</sup>

## 2. Fourier Transform Infra-red Spectroscopy

The absorbance of an IR band is described by the Beer-Lambert law:<sup>5</sup>

$$\log\left(\frac{I_0}{I}\right) = A = acd\#1$$

where a is the absorbance coefficient, c is the sample concentration, d is the pathlength,  $I_0$  is the background intensity and I is the measured transmitted intensity. As such the integrated intensity of an absorbance band should be proportional to the concentration of the species responsible for the vibration of the band.

This analysis makes the following assumptions:

- Parallel monochromatic light.
- No stray light.
- Parallel entrance and exit planes.
- Small homogeneous particle size and distribution.

• Fixed pathlength (sample thickness).

Though these are not strictly obeyed in the experimental setup used here, published literature has shown that despite the additional complications in ATR-FTIR experiments, a linear relationship exists between concentration and the integrated intensity of the absorbance bands, provided that the particle sizes of the components are comparable and considerably less than the area sampled in the experiment.<sup>6</sup>

Despite this, the lack of control over path length, and the difficulty of creating a calibration curve, as both ball milling and pelletisation seem to have an effect on ZIF-8 crystallinity that depends on its concentration relative to the inorganic glass, means that a completely quantitative comparison between IR spectra cannot be achieved. Despite this, a relative measure of the amount of ZIF-8 can be obtained by taking a ratio between the integrated intensity of a band from the ZIF-8 and one from the inorganic glass (Fig S12-S23).

A background was fitted to the data such that it was flat in the < 1500 cm<sup>-1</sup> region, and the ZIF-8 band, at approx. 1440 cm<sup>-1</sup>, and the inorganic glass band, at approx. 910 cm<sup>-1</sup>, were fitted with Lorentzian peaks and their areas obtained. These bands were chosen as being the only bands with negligible overlap between the two components. A ratio was then reported for each sample:

$$R = \frac{\int_{1360}^{1510} A(v) \, dv}{\int_{975}^{975} A(v) \, dv} #2$$

where A(v) is the measured absorbance as a function of wavenumber v. When the ZIF-8 band was completely absent a ratio of 0 was reported to indicate that the amount of intact ZIF-8 present was below the limits measurable by this method (Table S3). All data analysis was done in Fityk.<sup>4</sup>

#### 3. Analysis of the D<sub>2</sub>O <sup>1</sup>H Nuclear Magnetic Resonance (NMR) Spectroscopy

All the <sup>1</sup>H NMR samples contained an extra peak located between 7.4 and 8.1 ppm, which previous studies on ZIF frameworks digested by the same solvent system have identified as being due to D<sub>2</sub>O, which is reported as being highly variable in both its position and shape,<sup>7</sup> with reported peak positions ranging from 3.5 to 6 ppm for the 'D<sub>2</sub>O' peak and occasionally observed peak shapes that resemble solid spectra rather than the expected sharp Lorentzian. In our 15 wt% ZIF-8 powder sample, the extra peak is at a higher shift, approximately 8.1 ppm, and possesses a symmetric Lorentzian peak profile characteristic of a liquid.<sup>8</sup> However in our ZIF-8 control, 15 wt% ZIF-8 pellet and 15 wt% ZIF-8 450 °C 30 min samples, the extra peak is found at a lower shift, 7.4 – 7.6 ppm, and possesses a peak profile more akin to a solid.<sup>9</sup> Our extra peak is at a substantially higher ppm than is expected from H<sub>2</sub>O in DMSO, 3.33 ppm.<sup>10</sup> Based on the chemical shift, there are two options: H<sub>3</sub>O<sup>+ 11,12</sup> and DMF<sup>10</sup> have both been reported at approximately 8 ppm in DMSO. We have strong reason to believe our extra peak located between 7.4 and 8.1 ppm is from H<sub>3</sub>O<sup>+</sup>; the peak's sensitivity to its environment is confirmed by its position variability (Figure S26), unlike the DMSO peak which is consistently found at 2.51 ppm in all of our proton NMR spectra (Figure S27). This also matches perfectly with trends observed by

Frentzel-Beyme *et al.*, <sup>7</sup> whose DMSO peak is always located at 2.5 ppm in all spectra, while the 'D<sub>2</sub>O' shows up in the range 3.5 - 6 ppm. Furthermore, since DMSO is often a wet solvent and we have added D<sub>2</sub>O as a solvent, a water-related peak is the most logical. Thus, we label the extra peak in our system as (H,D)<sub>3</sub>O<sup>+</sup> in the proton NMR spectra in this paper.

Unfortunately,  $D_2O$  (and likely  $D_3O^+$ ) can easily exchange with acidic protons in the system, rendering acidic protons from the sample 'invisible' and producing visible  $(H,D)_3O^+$ . This exchange process is employed as a technique called ' $D_2O$  shake' for the express purpose of identifying acidic protons, and works extremely efficiently on any acidic protons.<sup>13</sup> Interestingly, the exchange between water and acidic protons is a continuous process happening at rates sufficiently fast to result in a single resonance peak located between the two starting proton resonances ( $H_2O$  and acidic proton in this case). This could be the reason that the  $H_3O^+$  peak is extremely sensitive to the NMR tube contents. As a result of this exchange, the hydronium proton peak is an averaged resonance of the electronic environments participating in acid-base reactions and possible hydrogen bonding. A relevant example is the proton exchange found between  $D_2O$  and the NH of an imidazole-based cation.<sup>14</sup>

On the other hand, the DMSO protons experience no exchange, no hydrogen bonding and are very stable. Looking at our 15 wt% ZIF-8 powder sample, we see that the  $H_3O^+$  peak is much larger and located at a higher ppm than the corresponding peaks in the other samples. For the 15 wt% ZIF-8 powder sample, we had to add more fresh solvent to this sample to make it the correct height in the NMR tube, thus more  $H_3O^+$  is present in this sample. In addition to being much larger, much more Lorentzian and at a higher ppm, this added  $H_3O^+$  from water contamination of the DCI/D<sub>2</sub>O, appears to have an effect on the sample peak shifts as well, perhaps indicating the strong interactions between ZIF-8 linker protons and -OH species.<sup>15</sup> It has been shown that stronger or more H-bonding can substantially affect the chemical shift of water,<sup>16</sup> thus the ppm of  $H_3O^+$  is highly sensitive. Again, the DMSO peak position is unaffected by the change in acidity or  $[H_3O^+]$  confirming its lack of H-interactions or proton-exchange.

Although the dependence of the  $H_3O^+$  on the acidity of the environment and available acidic protons explains the variation in the  $H_3O^+$  peak position, it does not immediately explain the variance in peak shape. Again, our ZIF-8 control, 15 wt% ZIF-8 pellet and 15 wt% ZIF-8 450 °C 30 min samples and some of the 'D<sub>2</sub>O' peaks from Frentzel-Beyme *et al.*<sup>9</sup> present solid-like line shapes. Such a line shape is clear evidence of slow orientational-averaging of the sample molecules, and resembles that found for water introduced into mesoporous carbon.<sup>17</sup> Thus, the peak shape likely indicates bound hydronium cations, perhaps associated strongly to the negatively charged ZIF-8 linkers or oxygens of the inorganic glass. Bound  $H_3O^+$  is less in-solution and therefore does not affect the solvent environment as much as free  $H_3O^+$ . As such the samples with solid-like peaks, i.e. the ZIF-8 control, the pellet and heat-treated samples have sample peaks at very consistent chemical shifts. On the other hand, due to the additional solvent, the 15 wt% ZIF-8 powder sample has a large Lorentzian  $H_3O^+$  peak, indicative of a liquid or free  $H_3O^+$ , likely affecting the solvent pH more and therefore the 15 wt% ZIF-8 powder sample peaks are at a different chemical shift from our other samples.

Finally, when Frentzel-Beyme *et al.* <sup>7</sup> examined a drop of  $DCl/D_2O$  in DMSO, they reported unknown peaks at 0.85 and 1.25 ppm; these peaks match well with those for  $-CH_3$  and  $-CH_2$  in *n*-hexane (0.86 and 1.25 ppm, respectively) reported previously in the literature.<sup>10</sup> This result likely indicates a reaction occurring between the acidic DCl and polyethylene cap or syringe plunger, as these two  $-CH_3$ 

and -CH<sub>2</sub> peaks are clear despite only one drop of DCI/D<sub>2</sub>O was introduced. Our spectra also contain these peaks (Figure S28), but they are very small compared to the sample and solvent peaks and can only be observed when this region is magnified substantially (approximately 10x magnification) and cannot be observed at the same scale as the other features (Figures S26 and S27). While sample peaks and analysis of the relative amount of 2-methylimidazole linker seem relatively unaffected, nonetheless, these two results indicate caution must be exercised when using this acidic solvent mixture in solution NMR of ZIFs.

## 4. Scanning Electron Microscopy (SEM) and Image analysis

Quantitative analysis of the size distributions of these dispersed samples of ZIF-62 and ZIF-8 was conducted using the Fiji <sup>18</sup> distribution of ImageJ<sup>19</sup> and Ilastik <sup>20</sup> via the following steps:

- 1. The raw data was loaded into ImageJ and calibrated using the field of view of each image.
- 2. Features such as remnant particle agglomerates, cracks in the carbon tape and the data bar were removed from the image using ImageJ to highlight them and Ilastik to create a mask which was then applied to the raw image.
- 3. ZIF particles were identified in these masked image files using Ilastik. A pixel classification, with all features selected at all length scales, was trained manually. The simple segmentation images were then exported.
- 4. A final stage of image processing was conducted in ImageJ to clean the images. This consisted of dilation and hole filling algorithms, followed by erosion in order to fill small holes and smooth corners. This was then followed by despeckling to get rid of errant pixels in the image. This produced 'cow-plots' of dark ZIF particles on a white background.
- 5. The 'Analyze Particles' tool in ImageJ was then used to evaluate the particle sizes in each image. A minimum particle size of 10 pixels was used in each case to remove any remaining noise.



#### 5. PXRD of ZIF-8 and Evacuated Powder Mixtures

Figure S1: Pawley refinement of evacuated ZIF-8  $R_{wp}$  = 6.56. The refined unit cell parameter was



17.034626 ± 0.000686 Å, using a starting parameter (17.00517 Å) taken from.<sup>21</sup>

**Figure S2:** Powder X-ray diffraction patterns of the evacuated ZIF-8: inorganic glass mixtures, 5– 30 wt% ZIF-8.

Sample	% Sample Mass @ 200 °C	% Sample Mass @ 450 °C	% Sample Mass @ 480 °C	% Sample Mass @ 550 °C	Glass Transition (Tg) / °C	Recrystallisation Temperature (T <sub>c</sub> ) / °C
Inorganic Control Replicate 1	99.74	99.17	99.12	99.11	352	529
Inorganic Control Replicate 2	99.59	98.90	98.84	98.78	354	528
5 wt% ZIF-8	99.91	98.52	98.23	97.64	350	523
10 wt% ZIF-8	99.85	97.94	97.38	95.87	357	515
15 wt% ZIF-8	99.87	97.16	96.39	94.46	360	518
30 wt% ZIF-8	99.81	97.11	95.94	91.94	361	
ZIF-8 Control Replicate 1	99.71	97.23	96.67	93.25		
ZIF-8 Control Replicate 2	99.53	96.73	96.06	93.85		
ZIF-8 Control Replicate 3	99.52	97.17	96.66	94.74		

## 6. Thermal Properties (DSC and TGA) Results

**Table S1:** Thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) results for the ZIF-8:  $78([Na_2O]_{1.6}[P_2O_5])-22([AIO_{1.5}][AIF_3]_{0.7})$  samples heated to 600 °C at 10 °C/min under Argon.



**Figure S3:** Differential scanning calorimetry (DSC) curves of the ZIF-8, inorganic glass and composite samples. The inorganic glass transition ( $T_g^{\text{Inorg.}}$ ) and recrystalisation temperature ( $T_c^{\text{Inorg.}}$ ) are indicated. Inset: As above but shown over the full data range.

## **11. PXRD of Pellet Samples and Controls**



**Figure S4:** Powder X-ray diffraction patterns of the background subtracted ZIF-8 controls and the curve fit, at approximately 7.3, 12.7 and 18.0  $^{\circ}$  2 $\theta$  (cyan), used in the relative crystallinity quantification.



Figure S5: Powder X-ray diffraction patterns of the inorganic glass controls.



**Figure S6:** Powder X-ray diffraction patterns of the background-subtracted 5 wt% ZIF-8 samples and the curve fit, at approximately 7.3, 12.7 and 18.0 °  $2\theta$  (cyan), used in the relative crystallinity quantification.



**Figure S7:** Powder X-ray diffraction patterns of the background subtracted 10 wt% ZIF-8 samples and the curve fit, at approximately 7.3, 12.7 and 18.0 °  $2\theta$  (cyan), used in the relative crystallinity quantification.



**Figure S8**: Powder X-ray diffraction patterns of the background subtracted 15 wt% ZIF-8 samples and the curve fit, at approximately 7.3, 12.7 and 18.0 °  $2\theta$  (cyan), used in the relative crystallinity quantification.



**Figure S9:** Powder X-ray diffraction patterns of the background subtracted 30 wt% ZIF-8 samples and the curve fit, at approximately 7.3, 12.7 and 18.0  $^{\circ}$  2 $\theta$  (cyan), used in the relative crystallinity quantification.

**Table S2:** Relative crystallinity results for the ZIF-8 controls and X wt% ZIF-8 samples.

Sample	Relative Crystallinity (%)	Error (%)	Fit R <sup>2</sup>
ZIF-8 Evac.	100.0	0.0	0.997
ZIF-8 Pressed Pellet	79.8	13.2	0.994
ZIF-8 450 C 30 min	74.9	7.9	0.997
ZIF-8 480 C 1 min	71.7	6.5	0.997
30 wt% ZIF-8 Evac	41.9	6.2	0.971
30 wt% ZIF-8 Pressed Pellet	15.5	1.6	0.995
30 wt% ZIF-8 450 C 30 min	9.6	1.5	0.997
30 wt% ZIF-8 480 C 1 min	10.7	1.0	0.997
15 wt% ZIF-8 Evac	7.8	0.2	0.996
15 wt% ZIF-8 Pressed Pellet	6.4	0.5	0.993
15 wt% ZIF-8 450 C 30 min	2.9	0.7	0.989
15 wt% ZIF-8 480 C 1 min	1.0	0.5	0.808
10 wt% ZIF-8 Evac	6.1	0.2	0.995
10 wt% ZIF-8 Pressed Pellet	6.7	1.2	0.995
10 wt% ZIF-8 450 C 30 min	6.1	6.0	0.978
10 wt% ZIF-8 480 C 1 min	0.0	0.0	0.613
5 wt% ZIF-8 Evac	2.3	0.3	0.953
5 wt% ZIF-8 Pressed Pellet	2.8	0.2	0.969
5 wt% ZIF-8 450 C 30 min	0.0	0.0	0
5 wt% ZIF-8 480 C 1 min	0.0	0.0	0



12. FTIR Spectra of Samples and Controls

**Figure S10:** FTIR spectra of the ZIF-8 controls, dashed droplines indicate positions of peaks reported in the literature to occur on decomposition of ZIF-8.<sup>22</sup>



Figure S11: FTIR spectra of the inorganic glass controls.



**Figure S12:** FTIR spectrum of the 5 wt% ZIF-8 pressed pellet. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted infra-red



spectrum (black) with fitted peaks (red).

**Figure S13:** FTIR spectrum of the 5 wt% ZIF-8 450 °C 30 min sample. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR spectrum (black) with fitted peak (red).



**Figure S14:** FTIR spectrum of the 5 wt% ZIF-8 480 °C 1 min sample. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR spectrum



(black) with fitted peak (red).

**Figure S15:** FTIR spectrum of the 10 wt% ZIF-8 pressed pellet. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR spectrum (black) with fitted peaks (red).



**Figure S16:** FTIR spectrum of the 10 wt% ZIF-8 450 °C 30 min sample. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR



spectrum (black) with fitted peaks (red).

**Figure S17:** FTIR spectrum of the 10 wt% ZIF-8 480 °C 1 min sample. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR spectrum (black) with fitted peak (red).



**Figure S18:** FTIR spectrum of the 15 wt% ZIF-8 pressed pellet. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR spectrum



(black) with fitted peaks (red).

**Figure S19:** FTIR spectrum of the 15 wt% ZIF-8 450 °C 30 min sample. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR spectrum (black) with fitted peaks (red).



**Figure S20:** FTIR spectrum of the 15 wt% ZIF-8 480 °C 1 min sample. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR spectrum (black) with fitted peaks (red).



**Figure S21** FTIR spectrum of the 30 wt% ZIF-8 pressed pellet. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR spectrum (black) with fitted peaks (red).



**Figure S22:** FTIR spectrum of the 30 wt% ZIF-8 450 °C 30 min sample. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR



spectrum (black) with fitted peaks (red).

**Figure S23:** FTIR spectrum of the 30 wt% ZIF-8 480 °C 1 min sample. Dashed droplines indicate positions of ZIF-8 decomposition peaks reported in the literature.<sup>22</sup> Inset: Background subtracted FTIR

Sample	Area ZIF-8 Band	Area Inorganic glass band	Ratio	Fit R <sup>2</sup>
30 wt% ZIF-8 Pressed Pellet	3.160	12.183	0.259	0.926
30 wt% ZIF-8 450 C 30 min	2.379	12.941	0.184	0.973
30 wt% ZIF-8 480 C 1 min	2.340	15.023	0.156	0.970
15 wt% ZIF-8 Pressed Pellet	0.836	14.998	0.056	0.967
15 wt% ZIF-8 450 C 30 min	0.741	15.350	0.048	0.979
15 wt% ZIF-8 480 C 1 min	0.814	15.828	0.051	0.973
10 wt% ZIF-8 Pressed Pellet	0.704	23.547	0.030	0.968
10 wt% ZIF-8 450 C 30 min	0.668	17.594	0.038	0.983
10 wt% ZIF-8 480 C 1 min	0	12.7465	0.000	0.972
5 wt% ZIF-8 Pressed Pellet	0.500	20.755	0.024	0.979
5 wt% ZIF-8 450 C 30 min	0	24.390	0.000	0.979
5 wt% ZIF-8 480 C 1 min	0	20.602	0.000	0.974

spectrum (black) with fitted peaks (red).

**Table S3.** Relative proportions of ZIF-8 and Inorganic glass as determined by integration of FTIR absorbance bands.

#### 13. <sup>1</sup>H NMR Spectra of Samples and Controls



**Figure S24:** <sup>1</sup>H NMR spectra of the ZIF-8 control and the 15 wt% ZIF-8.  $H_a$  and  $H_b$  are the imidazole ring -CH and -CH<sub>3</sub> group protons, respectively. Please see methods for discussion on assignment of solvent peaks.



**Figure S25**: <sup>1</sup>H NMR spectra of the 15 wt% ZIF-8 pellet before and after heat treatment at 450 °C for 30 mins (blue vs. red) I.  $H_b$ , the imidazole ring -CH protons II.  $H_a$ , methyl -CH<sub>3</sub> group protons.



**Figure S26:** High ppm region of the ZIF-8 control and the 15 wt% ZIF-8 samples. H<sub>a</sub>, imidazole ring -CH protons. Please see methods for discussion on assignment of solvent peaks.



Figure S27: Low ppm region of the ZIF-8 control and the 15 wt% ZIF-8 samples.  $H_b$ , methyl -CH<sub>3</sub> group protons.



**Figure S28:** Greatly magnified (x10) <sup>1</sup>H NMR spectra of the samples in the region 0.5 - 1.5 ppm showing the -CH<sub>2</sub> and -CH<sub>3</sub> peaks believed to result from reaction between polyethylene cap/syringe and acidic solvent. See methods for more details.

Table S4: <sup>1</sup> H NMR chemical shifts of the ZIF-8 control and the 15 wt% ZIF-8 samples. Letters correspond
to peaks in <sup>1</sup> H NMR spectra. See methods for an explanation of the unique chemical shifts for the 15

Sample	Chemical Shift (ppm)				
	Imid-(H <b>a</b> )	CH₃-(H <b>b</b> )	DMSO (centre)	$D_2O$	
ZIF-8 Control	7.368	2.481	2.509	7.425	
15 wt% ZIF-8 Powder	7.214	2.391	2.510	8.073	
15 wt% ZIF-8 Pellet	7.362	2.475	2.509	7.592	
15 wt% ZIF-8 450 °C 30 mins	7.365	2.478	2.509	7.584	

wt% ZIF-8 powder sample.

Sample	Integral (Arb)		[Imid-H]	[Imid-H]	[Imid-H]	Relative to	
Sample	Imid-H	-CH₃	DMSO	/[CH <sub>3</sub> ]	/[Imid-H + $CH_3$ ]	/[DMSO]	control
ZIF-8 Control	1	1.511	2.225	0.66	0.40	0.45	
15 wt% ZIF-8 Powder	1	1.612	15.620	0.62	0.38	0.06	0.14
15 wt% ZIF-8 Pellet	1	1.548	15.669	0.65	0.39	0.06	0.14
15 wt% 450 °C 30 mins	1	1.629	57.846	0.61	0.38	0.02	0.04

 Table S5: <sup>1</sup>H NMR peak integrals of the ZIF-8 control and the 15 wt% ZIF-8 samples, along with calculated values such as [Imid-H]/[DMSO] and the [Imid-H]/[DMSO] relative to the ZIF-8 control



14. Scanning Electron Microscopy of ZIF-8 and ZIF-62 powders

Figure S29: SEM images of undispersed evacuated ZIF-8 (Imaged using a FEI Nova NanoSEM).



Figure S30: SEM images of undispersed evacuated ZIF-62 (Imaged using a FEI Nova NanoSEM).



**Figure S31:** SEM images of evacuated and dispersed ZIF-8 (left) and the same images after the processing steps necessary to extract particle size information (right) (Imaged using a Thermo ScientificTM Phenom ProX).



**Figure S32.** SEM images of evacuated and dispersed ZIF-62 (left) and the same images after the processing steps necessary to extract particle size information (right) (Imaged using a Thermo ScientificTM Phenom ProX).



**Figure S33:** Histogram of evacuated and dispersed ZIF-8 particle sizes determined by SEM. The number in each size range is normalised by the total number of measured ZIF-8 particles (N = 732) to represent the proportion of particles within a given size range.



**Figure S34:** Histogram of evacuated and dispersed ZIF-62 particle sizes. The number in each size range is normalised by the total number of measured ZIF-62 particles (N = 709) to represent the proportion of particles within a given size range.

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