Supporting Information

Multi-role conductive hydrogels for flexible transducers regulated by MOFs for monitoring of human activities and electronic skin functions

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Text 1

Synthesis of Zn-MOF

First the Zinc metal organic framework (Zn-MOF) was developed utilizing the hydrothermal synthesis method. Trimesic acid was chosen as the organic linker, while $Zn(NH_3)_2$ employed as the precursor metal. The standard procedure involved dissolving of 3g $Zn(NH_3)_2$ in a 60ml solution composed of water, DMF, and ethanol, maintaining a 1:1:1 ratio. Subsequently, 1.5g of TMA was introduced into the mixture and stirred for 30 minutes at room temperature. Following this, the homogeneous blend was carefully transferred into a 100ml autoclave. The autoclave was subjected to a controlled temperature of 120°C within an oven for a duration of 12 hours. This thermal

treatment yielded distinctive white crystals, which were subsequently isolated, subjected to multiple rounds of washing with ethanol and water, and then carefully filtered. The end product was subjected to vacuum drying and set aside for subsequent comprehensive characterizations.

Characterization

Fourier-transformed spectroscopy was utilized to discern the functional groups of TMA within the Zn-MOF, and their respective spectra are depicted in Figure S1. As per existing literature, the absorption peak at 3454 cm-1 signifies the OH stretching vibration of a water molecule, complemented by deformation vibrations at 719 cm-1. These observations suggest that water not only acts as a solvent but also assumes a pivotal role in the Zn-MOF preparation[1]. Furthermore, the discernible bands at 1627-1579 cm-1 and 1453-1378 cm-1 are attributed to the asymmetric and symmetric vibrations of the interconnected carboxylic groups, affirming the successful synthesis of Zn-MOF. This conclusion gains further substantiation from the presence of a distinctive band at 578 cm-1, indicating the characteristic vibration of metal ions and TMA (O-Zn)[2-4].

Supporting Information

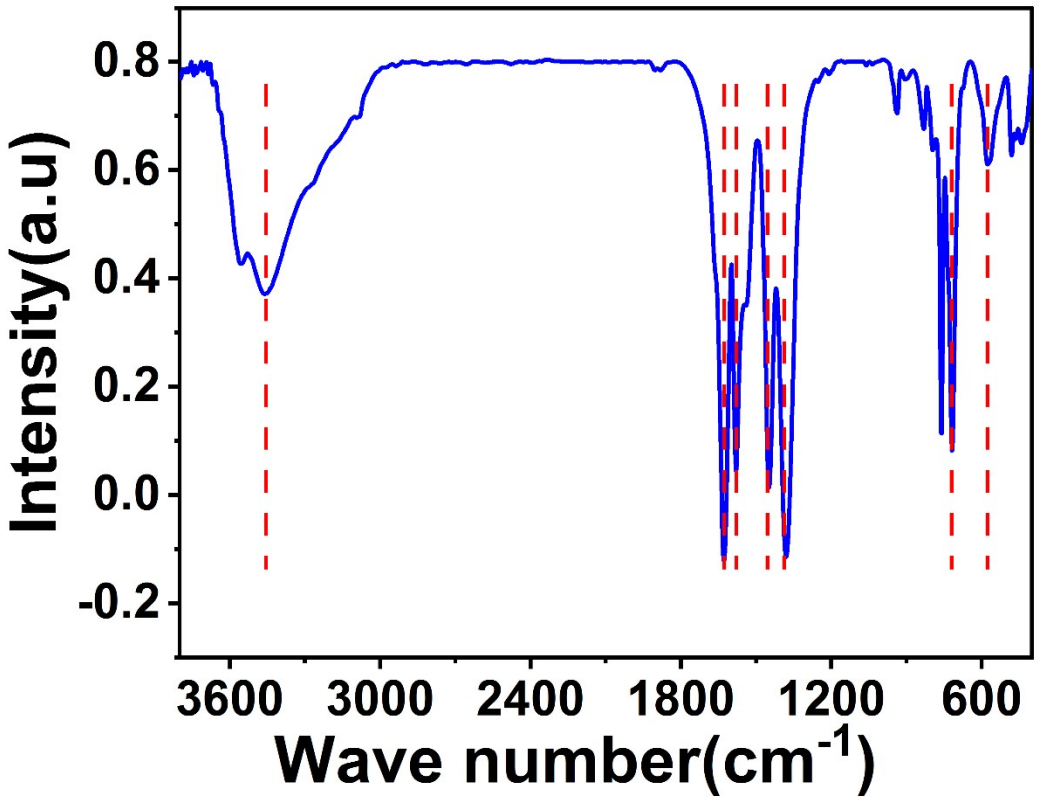


Figure S1 FTIR spectra of the prepared Zinc based metal organic frame work.

The X-ray diffraction analysis of the synthesized MOFs is depicted in Figure S1. This graphical representation reveals and affirming the successful preparation of the Zn-MOF. Importantly, there is no evidence of peak splitting, indicating the presence of a single-phase crystallographic structure within the Zn-MOF. According to the previously reported literatures, in the XRD patterns Zn peaks can be observed at 2 thetas of 15.6, 18.5, 19.7, 20.2, 22.4, 25.6, 31.8, 34.6, and 36.2, All these values suggested the successfully synthesis of the Zn-MOF[5-7].

Supporting Information

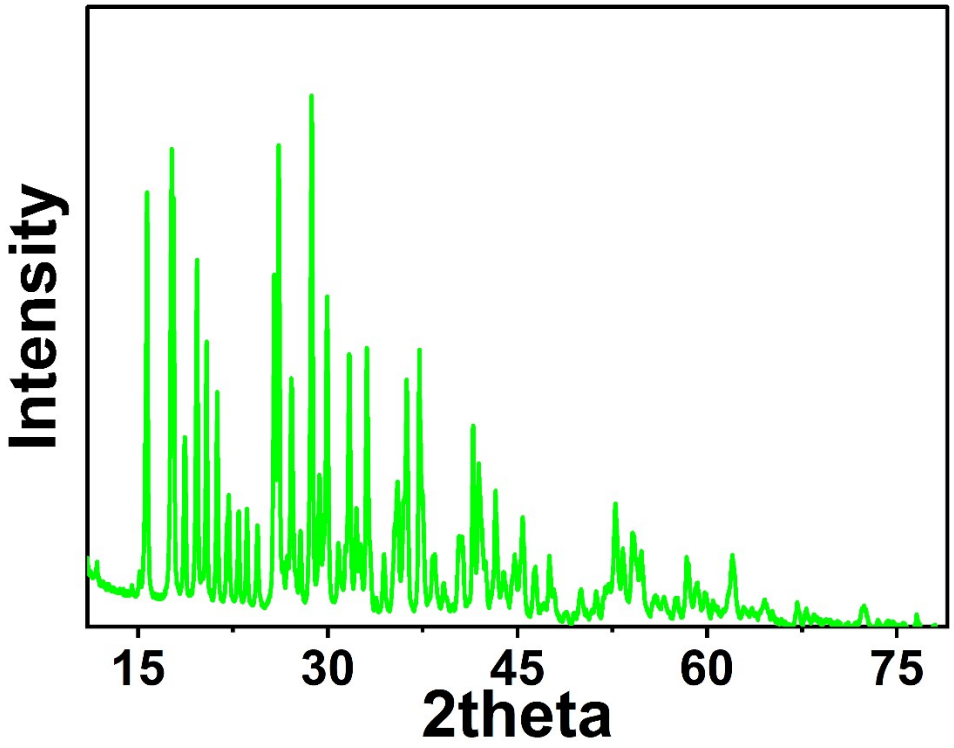
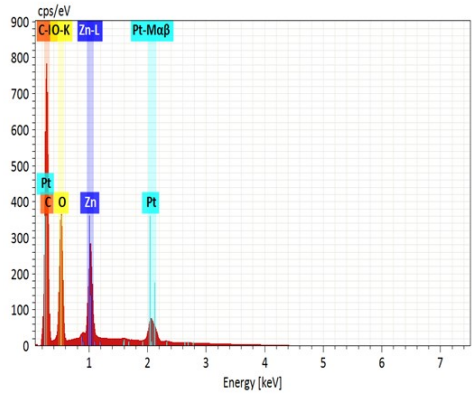


Figure S2 XRD analysis of the prepared Zn-MOF.

Furthermore, the Zn-MOF underwent characterization using Energy-Dispersive X-ray Spectroscopy (EDS) and scanning electron microscopy (SEM) as given in Figure. EDS analysis, as depicted in Figure a and table b confirmed the presence of Zinc metal with the 24% in the MOF, as evidenced by the identified elemental peaks. Moreover, SEM images of the MOFs revealed a distinct cylindrical morphology, as illustrated in Figure c. However, according to the SEM image the size of the Zn-MOF was different in length.

Supporting Information

a



b

Map

Element	At. No.	Mass [%]	Mass Norm. [%]	Atom [%]	abs. error [%] (3 sigma)
C	6	30.41	35.01	51.67	9.44
O	8	31.87	36.69	40.65	10.01
Zn	30	24.58	28.30	7.67	4.28
Pt	78	0.00	0.00	0.00	0.00
		86.87	**100.00**	**100.00**	

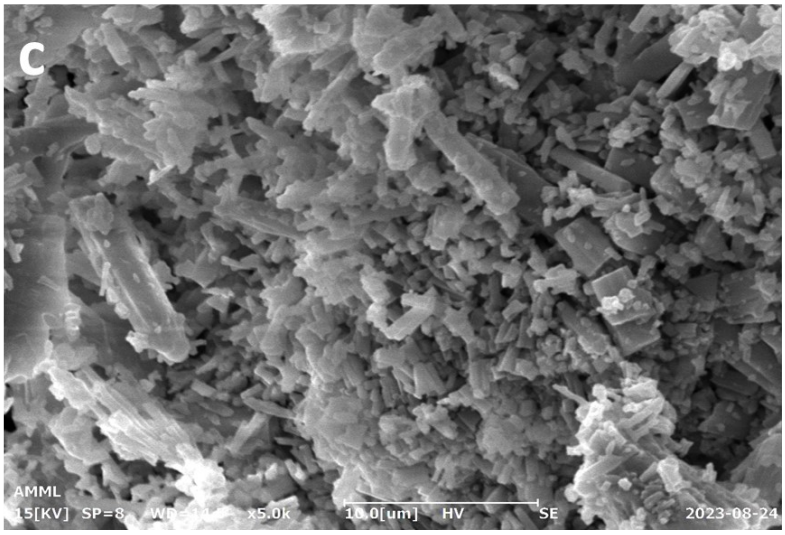


Figure. S3 (a-b) Illustration of the EDS analysis of the Zn-MOF (c) SEM study of the Zn-MOF.

Supporting Information

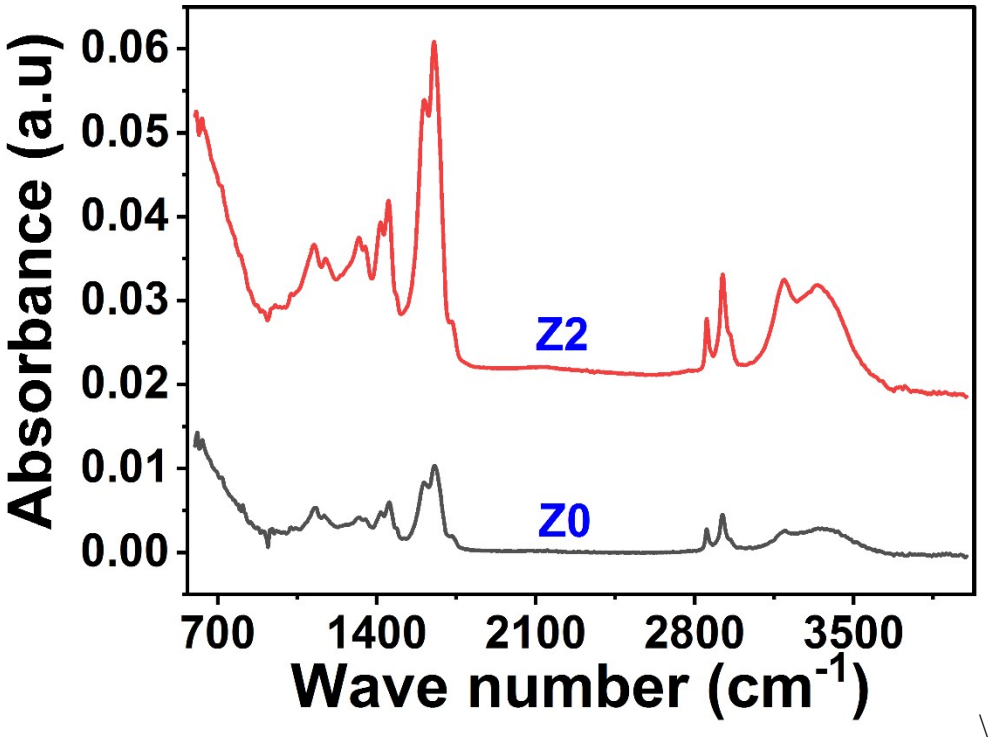


Figure S4 FTIR spectroscopy of the hydrogels

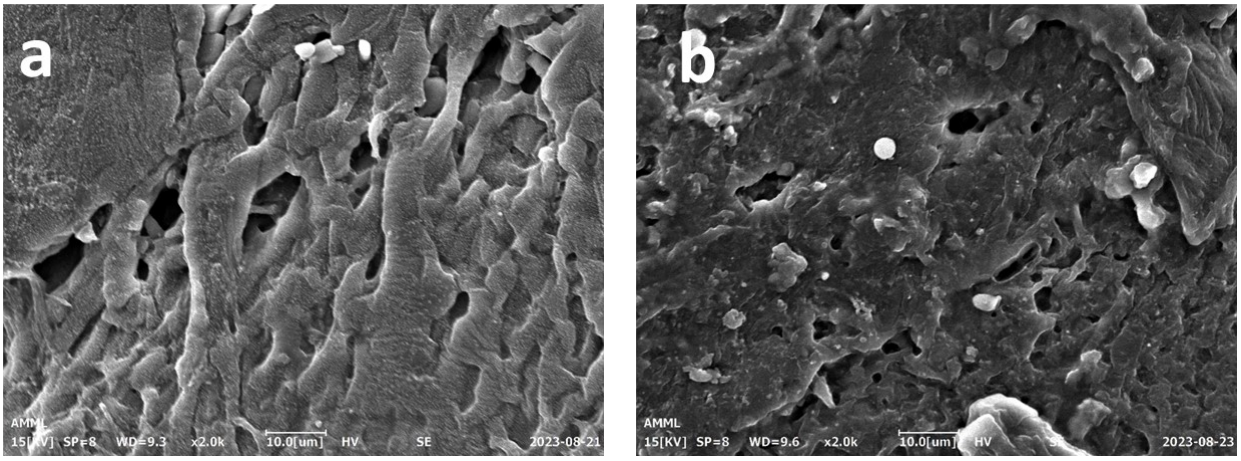


Figure S5 SEM images of the prepared hydrogels (a) Z0 and (b) Z2

Supporting Information

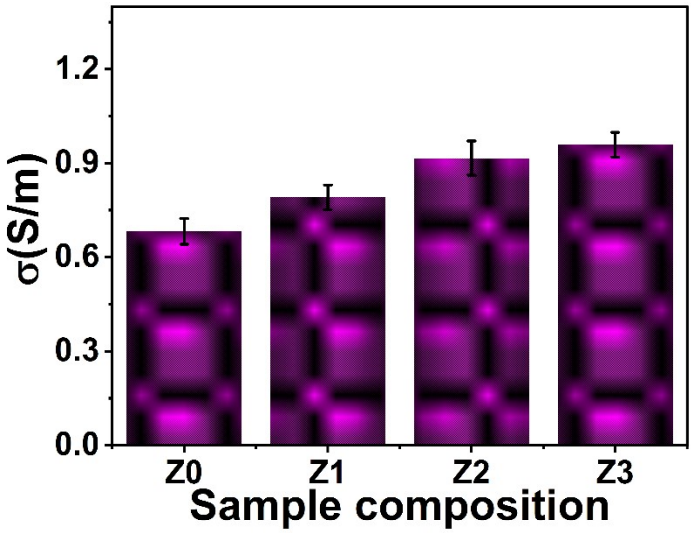


Figure S6 conductivity of the prepared p(DDMA-AM- DMAEMC) Zn-MOFs hydrogels.

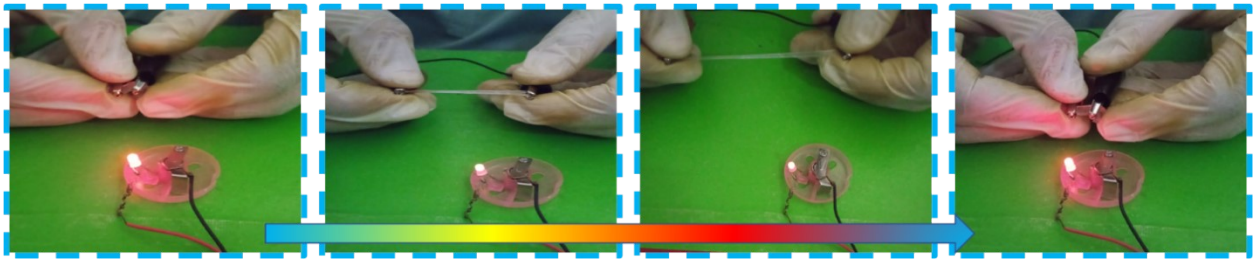


Figure S7. Visualization of the strain sensitivity of the p(DDMA-AM- DMAEMC) Zn-MOF hydrogels

Reference

1. Medina-Velazquez, D., et al., *An alkaline one-pot reaction to synthesize luminescent Eu-BTC MOF nanorods, highly pure and water-insoluble, under room conditions.* Journal of Nanoparticle Research, 2016. **18**: p. 1-10.
2. Tahier, T. and C.L. Oliver, *In situ variable-temperature single crystal X-ray diffraction studies of the single-crystal-to-single-crystal dehydration and rehydration of a mixed-ligand 2D zinc metal–organic framework using trimesate and 4, 4′-bipyridine-N, N′-dioxide as ligands.* CrystEngComm, 2015. **17**(46): p. 8946-8956.
3. Akbarzadeh, F., et al., *A novel synthesis of new antibacterial nanostructures based on Zn-MOF compound: design, characterization and a high performance application.* Heliyon, 2020. **6**(1).
4. Nazari, Z., M.A. Taher, and H. Fazelirad, *A Zn based metal organic framework nanocomposite: synthesis, characterization and application for preconcentration of cadmium prior to its determination by FAAS.* RSC advances, 2017. **7**(71): p. 44890-44895.

5. Rafiee, Z., *Fabrication of efficient Zn-MOF/COF catalyst for the Knoevenagel condensation reaction.* Journal of the Iranian Chemical Society, 2021. **18**(10): p. 2657-2664.
6. Ramish, S.M., A. Ghorbani-Choghamarani, and M. Mohammadi, *Microporous hierarchically Zn-MOF as an efficient catalyst for the Hantzsch synthesis of polyhydroquinolines.* Scientific Reports, 2022. **12**(1): p. 1479.
7. Li, T., et al., *Advances in transition-metal (Zn, Mn, Cu)-based MOFs and their derivatives for anode of lithium-ion batteries.* Coordination Chemistry Reviews, 2020. **410**: p. 213221.