Electronic Supplementary Material

New applications of dodecahedral bimetallic imidazolate frameworks in the robust and superior wear-resistant epoxy composites

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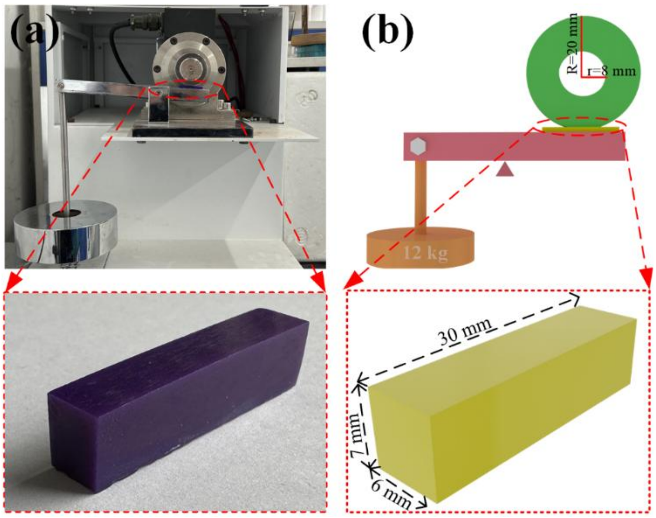
2. Experimental

2.3 Characterization

2.3.2 Performance testing

The tribological performance was assessed by the block-on-ring sliding wear test with an M-200 tribo-tester (Shanghai ZHONGLU Industrial Co., Ltd., China) under dry friction, of which the optical pictures and schematic drawing was shown in Scheme S1. The applied counterpart was a quenched 45# carbon steel ring (AISI 1045) with the hardness of 40~45 HRC and the surface roughness (Ra) of 0.4. The outer and internal ring sizes were Φ40 mm×10 mm and Φ16 mm×10 mm, respectively. All tests were conducted at room temperature, with a rotating speed (ω) of 100 rpm, a vertical load of 12 kg and a duration of 3600 s. Before each test, the steel ring was abraded by a No. 1000 metallographic abrasive paper, cleaned with cotton dipped in absolute alcohol and then dried in the air. The sample dimension was 30 mm in length, 7 mm in width and 6 mm in height. The curve of friction coefficient and the average value (μ) could be obtained directly from the outputs while the wear rate (Ws, $mm^3/N\cdot m$) was calculated according to the equation of $Ws = \Delta m/(\rho\cdot F\cdot L)$, where Δm was the difference of weight before and after abrasion (g), ρ denoted the density of sample (g/mm^3), F referred to the applied load (N) and L represented the sliding length (m) related to the sliding speed and time.



Scheme S1 The detailed tribological testing system: (a) optical image and (b) schematic drawing of testing machine and EP composites

3. Results and discussion

3.5 Thermal stability

$$T_S = 0.49[T_{5\%} + 0.6(T_{30\%} - T_{5\%})] \qquad (S1)$$

T_s is the statistical heat resistance index of the composites in terms of thermal fluidity and thermal stability, which is employed to reflect the resistance to heat flow before it is thermally damaged, and determined according to Equation S1[1]. Here, $T_{5\%}$ and $T_{30\%}$ represent the temperature when the weight loss fractions are up to 5% and 30%, respectively. T_{max} indicates the temperature at which the maximum decomposition rate is reached, and it is actually assigned to the peak temperature at the DTG curve.

$$\ln[\ln(1-\alpha)^{-1}] = (T - T_{max}) \cdot \frac{E_\alpha}{RT_{max}{}^2} + constant \qquad (S2)$$

A method proposed by Horowitz and Metzger[2] is employed to calculated the activation energy (E_α, kJ/mol) of thermal decomposition, which are expressed in Equation S2. Here, α represents the weight conversion fraction at a temperature of T (K). R is the gas constant, which equals 8.314 J/(mol·K). By linearly plotting the logarithmic term of $\ln[\ln(1-\alpha)^{-1}]$ against $(T-T_{max})$ at several different temperatures, a fitted line can be obtained, as shown in Fig. S1 and Table S1. Then, the activation energy of E_α can be calculated from the slope of fitted straight line.

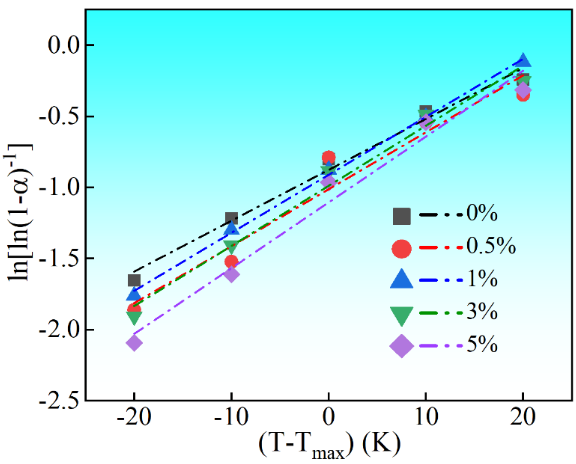


Fig. S1 Fitting plot of samples based on Horowitz and Metzger equation

Table S1 Fitting results of samples based on Horowitz and Metzger equation

Sample	Slop	Intercept	Fitted equation	Pearson's r
0%	0.0357	-0.8761	y=0.0357·x-0.8761	0.992
0.5%	0.0400	-1.0128	y=0.0400·x -1.0128	0.973
1%	0.0408	-0.9111	y=0.0408·x -0.9111	0.998
3%	0.0422	-0.9888	y=0.0422·x -0.9888	0.990
5%	0.0463	-1.1051	y=0.0463·x -1.1051	0.987

References:

[1] Usha Rani PH, Rajaprakash BM, Mohan N, Akshay Prasad M. Study on thermal and erosive wear behaviour of hard powders filled glass-epoxy composite. ***Materials Today: Proceedings***, 2020, 27: 2011-2016. doi: https://doi.org/10.1016/j.matpr.2019.09.049.

[2] Horowitz HH, Metzger G. A new analysis of thermogravimetric traces. ***Analytical Chemistry***, 1963, 35(10): 1464-1468. doi: https://doi.org/10.1021/ac60203a013.