

Table S1 the base information of all used materials

	Name	Chemical formula	Purity (%)	Supplier
Polymer ionic liquid	1-Vinylimidazole	C ₅ H ₆ N ₂	99%	Aladdin
	Ethyl bromide	C ₂ H ₅ Br	99%	Aladdin
	Propyl bromide	C ₃ H ₇ Br	99%	Aladdin
	Butyl bromide	C ₄ H ₉ Br	99%	Aladdin
	Amyl bromide	C ₅ H ₁₁ Br	99%	Aladdin
	Hexyl bromide	C ₆ H ₁₃ Br	99%	Aladdin
	Azodiisobutyronitrile	C ₈ H ₁₂ N ₄	99%	J&K Chemical
GO	Graphite	C	99.8%	Aladdin
	Sodiumnitrate	NaNO ₃	99%	supplier
	Potassium permanganate	KMnO ₄	99.5%	supplier
	Hydrogen peroxide	H ₂ O ₂	30%	supplier
Model fuel	N-octane	C ₈ H ₁₈	99.9%	supplier
	Thiophene	C ₄ H ₄ S	99%	supplier
	Benzothiophene	C ₈ H ₆ S	99%	Aladdin
	Dibenzothiophene	C ₁₂ H ₈ S	99%	Aladdin

Table S2 BBD experiment design and response result for desulfurization of thiophene

Run	Factors				Experimental
	A:Temperature	B:Mass	C:Oxygen flux	D:Stirring speed	
	(°C)	(g)	(L/min)	(rpm)	
1	60	0.08	0.5	1000	89.91
2	30	0.11	1	600	84.32
3	60	0.08	0.5	200	78.3
4	90	0.08	1	200	81.68
5	30	0.08	1.5	600	85.11
6	90	0.08	0.5	600	87.51
7	30	0.08	1	200	89.44

8	60	0.08	1	600	97.34
9	60	0.05	0.5	600	83.57
10	60	0.05	1	200	76.94
11	60	0.11	1	1000	93.05
12	60	0.11	1.5	600	91.96
13	60	0.08	1	600	97.79
14	60	0.08	1	600	98.02
15	60	0.11	0.5	600	89.33
16	60	0.11	1	200	84.79
17	90	0.11	1	600	89.36
18	60	0.08	1	600	98.12
19	60	0.05	1.5	600	84.7
20	60	0.05	1	1000	88.07
21	30	0.05	1	600	78.19
22	30	0.08	1	1000	83.61
23	30	0.08	0.5	600	77.43
24	90	0.08	1.5	600	91.71
25	90	0.08	1	1000	89.96
26	90	0.05	1	600	86.43
27	60	0.08	1	600	97.64
28	60	0.08	1.5	200	85.69
29	60	0.08	1.5	1000	94.76

Table S3 Analysis of variance (ANOVA) results for removal thiophene

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	1028.08	14	73.43	8.66	0.0001	significant
A-temperature	67.93	1	67.93	8.01	0.0133	
B-m	101.56	1	101.56	11.98	0.0038	
C-oxygen flux	64.77	1	64.77	7.64	0.0152	

D-stirring speed	150.66	1	150.66	17.78	0.0009	
AB	2.56	1	2.56	0.3020	0.5913	
AC	3.03	1	3.03	0.3572	0.5596	
AD	49.77	1	49.77	5.87	0.0295	
BC	0.5625	1	0.5625	0.0664	0.8005	
BD	2.06	1	2.06	0.2430	0.6297	
CD	1.61	1	1.61	0.1903	0.6693	
A ²	306.42	1	306.42	36.15	< 0.0001	
B ²	243.59	1	243.59	28.74	0.0001	
C ²	160.18	1	160.18	18.90	0.0007	
D ²	192.09	1	192.09	22.66	0.0003	
Residual	118.66	14	8.48			
Lack of Fit	118.27	10	11.83	122.41	0.0002	significant
Pure Error	0.3865	4	0.0966			
Cor Total	1146.74	28				
