

Electronic Supplementary Information of:

The experimental average refractive index of liquid crystals and its prediction from the anisotropic indices

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S1. Treatment of densities and refractive indices data

S1.1. Densities

The densities of the organic liquids were measured with a pycnometer from 18 to 60 °C. The data were fitted to the following model:

$$\rho(T) = Ce^{-\beta(T) \cdot T}, \quad \beta(T) = b_1T + b_0, \quad (\text{S1})$$

in which C , b_0 and b_1 are parameters. An example of the fit is shown in Fig. S1a for HMN.

The densities of the LC were measured with a pycnometer from 24 to 43 °C for 5CB and from 24 to 58 °C for MBBA. The data were fitted to the following model:

$$\begin{aligned} \rho_{\text{LC}}(T) &= [1 - H(T - T_{\text{NI}})] \rho_{0,\text{N}} e^{-\beta_{\text{N}}(T) \cdot T} + H(T - T_{\text{NI}}) \rho_{0,\text{I}} e^{-\beta_{\text{I}}(T) \cdot T}, \\ \beta_i(T) &= \beta_{i,1}T + \beta_{i,0}, \end{aligned} \quad (\text{S2})$$

in which $\rho_{0,\text{N}}$ and $\rho_{0,\text{I}}$ are parameters, β_{N} and β_{I} denote the nematic and isotropic thermal expansion coefficients, respectively, and $H(T - T_{\text{NI}})$ is a Heaviside-like step function centred at the nematic-isotropic transition temperature T_{NI} :

$$H(T - T_{\text{NI}}) = 1 - \frac{1}{1 + e^{\lambda(T - T_{\text{NI}})}}, \quad (\text{S3})$$

with λ as a smoothing parameter to mark the transition from nematic to isotropic; it was fixed to $\lambda = 6 \text{ K}^{-1}$. The results are plotted in Fig. S2. The densities were then interpolated at the temperatures at which the refractive indices of the isotropic mixtures were measured.

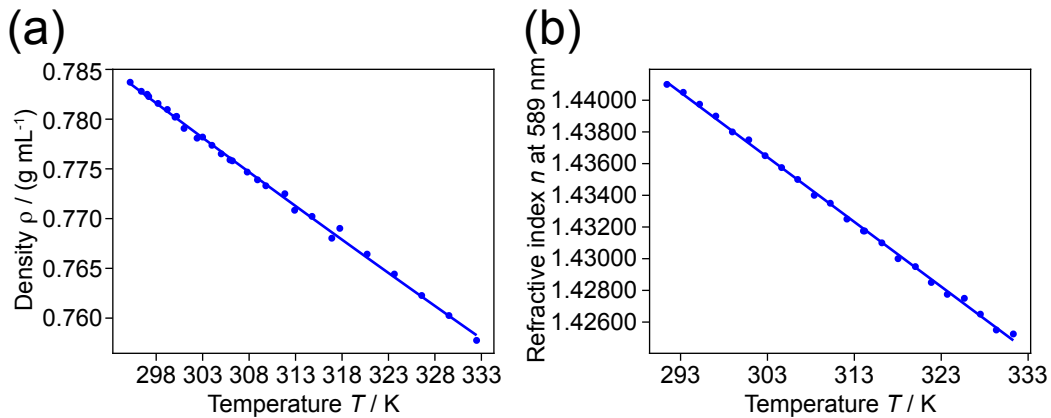


Figure S1. (a) Densities of HMN fitted to Eq. S1; (b) refractive indices of HMN fitted to Eq. S4.

S1.2. Refractive indices

The refractive indices of the organic liquids were fitted to a linear model:

$$n(T) = a_1T + a_0, \quad (\text{S4})$$

in which a_0 and a_1 are parameters. An example of the fit appears in Fig. S1b for HMN. These data were then interpolated at the temperatures at which the refractive indices of the isotropic mixtures were measured.

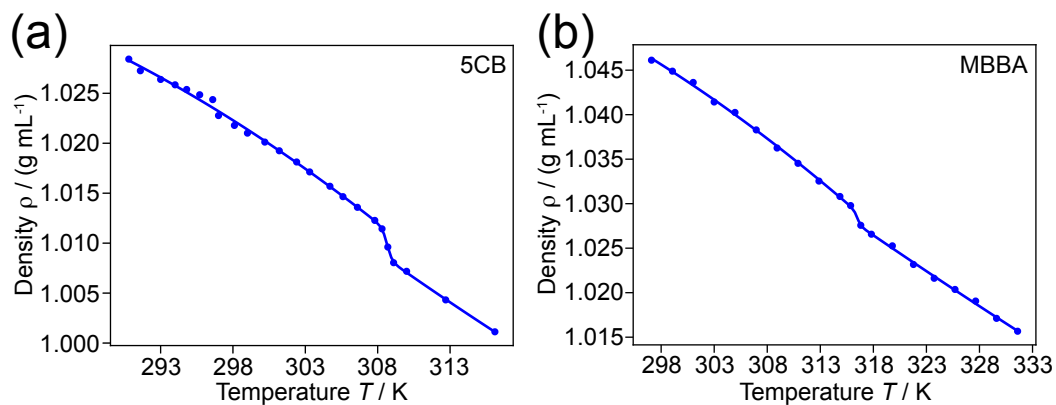


Figure S2. Densities of the LC (a) 5CB and (b) MBBA fitted to Eq. S2.

S2. Data tables of densities and refractive indices of liquid crystals, isotropic liquids and mixtures of liquid crystal + isotropic liquid

S2.1. Densities

S2.1.1. *N*-(4-methoxybenzylidene)-4-butylaniline (MBBA)

Table S1. Densities of liquid crystal MBBA.

Temperature / °C (±0.001)	Density / (g cm ⁻³) (±0.0003)
24.091	1.0461
26.064	1.0449
28.021	1.0436
29.995	1.0414
31.959	1.0403
33.962	1.0383
35.927	1.0363
37.896	1.0345
39.872	1.0325
41.848	1.0308
42.856	1.0298
43.813	1.0276
44.814	1.0266
46.789	1.0253
48.778	1.0232
50.730	1.0216
52.694	1.0204
54.638	1.0191
56.608	1.0171
58.593	1.0157

S2.1.2. 4-*n*-pentyl-4'-cyanobiphenyl (5CB)

Table S2. Densities of liquid crystal 5CB.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0004)
24.0	1.0233
26.4	1.0211
27.6	1.0200
29.6	1.0184
31.5	1.0163
32.4	1.0153
33.0	1.0147
34.1	1.0134
35.0	1.0121
35.6	1.0106
35.8	1.0089
37.0	1.0071
39.6	1.0045
40.4	1.0034
43.0	1.0019
24.0	1.0233
26.4	1.0211
27.6	1.0200
29.6	1.0184
31.5	1.0163
32.4	1.0153
33.0	1.0147
34.1	1.0134
35.0	1.0121
35.6	1.0106
35.8	1.0089
37.0	1.0071
39.6	1.0045
40.4	1.0034
43.0	1.0019
17.8	1.0284
18.6	1.0273
20.0	1.0264
21.0	1.0258
21.8	1.0254
22.7	1.0249
23.6	1.0244
24.0	1.0228
25.1	1.0218
26.0	1.0210
27.2	1.0201
28.2	1.0192
29.4	1.0181
30.3	1.0171
31.7	1.0157
32.6	1.0147

Table S2 continued from previous page

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0004)
33.6	1.0136
34.8	1.0123
35.3	1.0114
35.7	1.0096
36.1	1.0080
37.0	1.0072
39.7	1.0043
43.1	1.0011

*S2.1.3. Benzyl alcohol***Table S3.** Densities of benzyl alcohol.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0004)
24.0	1.0427
24.8	1.0426
26.0	1.0417
26.8	1.0409
28.2	1.0398
29.0	1.0392
30.1	1.0379
30.8	1.0373
31.6	1.0368
32.6	1.0358
34.5	1.0345
36.0	1.0334
37.0	1.0325
41.9	1.0285

*S2.1.4. Cinamaldehyde***Table S4.** Densities of cinamaldehyde.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0004)
22.8	1.0532
24.2	1.0517
25.6	1.0509
26.7	1.0499
27.6	1.0493
28.6	1.0482
29.6	1.0476
30.6	1.0467

Table S4 continued from previous page

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0004)
31.6	1.0459
32.7	1.0448
34.6	1.0438
36.6	1.0420
38.5	1.0403
40.3	1.0384
42.5	1.0367
42.9	1.0354

*S2.1.5. 1-decanol***Table S5.** Densities of 1-decanol.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0003)
21.8	0.8292
22.6	0.8283
23.8	0.8273
25.0	0.8266
26.4	0.8257
27.4	0.8251
28.2	0.8245
29.6	0.8236
31.0	0.8224
32.1	0.8219
33.4	0.8210
34.7	0.8202
35.9	0.8193
40.2	0.8156
43.3	0.8128

*S2.1.6. Glyceryl trioleate (GTO)***Table S6.** Densities of GTO.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0003)
24.103	0.9106
27.044	0.9085
30.019	0.9063
32.958	0.9045
35.916	0.9024
38.864	0.9003
41.834	0.8983

Table S6 continued from previous page

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0003)
44.796	0.8964
47.730	0.8943
50.675	0.8925
53.537	0.8905
56.617	0.8889

*S2.1.7. 2,2,4,4,6,8,8-heptamethylnonane (HMN)***Table S7.** Densities of HMN.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0002)
22.2	0.7837
23.4	0.7828
24.2	0.7823
25.2	0.7816
26.2	0.7810
27.2	0.7803
28.0	0.7791
29.4	0.7781
31.0	0.7774
32.0	0.7765
33.2	0.7758
34.8	0.7747
36.8	0.7733
39.9	0.7708
43.9	0.7680

*S2.1.8. 1-octanol***Table S8.** Densities of 1-octanol.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0003)
23.2	0.8251
24.2	0.8239
25.2	0.8233
26.2	0.8224
27.2	0.8219
28.2	0.8212
29.2	0.8204
30.0	0.8196
32.3	0.8186
31.2	0.8178

Table S8 continued from previous page

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0003)
32.3	0.8171
34.4	0.8163
35.3	0.8157
36.4	0.8146
38.5	0.8128
41.2	0.8111
44.1	0.8097

*S2.1.9. 2-octyl-1-dodecanol (2OD)***Table S9.** Densities of 2OD.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0003)
22.6	0.8388
23.6	0.8379
24.6	0.8373
25.8	0.8364
26.8	0.8359
27.5	0.8354
28.7	0.8342
29.8	0.8340
31.0	0.8329
32.0	0.8324
33.0	0.8320
34.0	0.8310
35.0	0.8308
36.2	0.8300
38.5	0.8274
40.4	0.8264
43.2	0.8248

*S2.1.10. 1,1,2,2-tetrabromoethane (TBE)***Table S10.** Densities of TBE.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.003)
23.0	2.960
24.0	2.957
25.0	2.955
26.0	2.953
27.2	2.950
28.1	2.948

Table S10 continued from previous page

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.003)
29.0	2.946
30.0	2.944
31.0	2.942
32.0	2.940
33.0	2.937
34.0	2.935
35.0	2.931
36.0	2.930
38.8	2.922
41.5	2.916

*S2.1.11. n-undecane***Table S11.** Densities of *n*-undecane.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0002)
22.8	0.7397
23.6	0.7391
24.7	0.7378
25.8	0.7371
26.8	0.7363
27.7	0.7355
28.6	0.7349
29.6	0.7341
30.7	0.7333
31.7	0.7324
32.6	0.7318
33.8	0.7307
35.0	0.7296
36.0	0.7291
38.1	0.7272
41.3	0.7249
43.2	0.7236

*S2.1.12. 1-undecanol***Table S12.** Densities of 1-undecanol.

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0003)
21.0	0.8338
22.0	0.8332
23.0	0.8325

Table S12 continued from previous page

Temperature / °C (±0.1)	Density / (g cm ⁻³) (±0.0003)
24.0	0.8318
26.0	0.8302
27.4	0.8292
28.1	0.8287
29.6	0.8276
30.6	0.8272
31.4	0.8265
32.6	0.8256
33.2	0.8255
34.6	0.8245
35.2	0.8239
36.2	0.8233
41.6	0.8193
44.6	0.8168

S2.2. Refractive indices

S2.2.1. Benzyl alcohol

Table S13. Refractive indices at 589 nm of benzyl alcohol.

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.829	1.53825
20.641	1.53750
22.457	1.53675
24.291	1.53600
26.169	1.53525
28.033	1.53450
29.923	1.53375
31.781	1.53275
33.644	1.53175
35.508	1.53050
37.360	1.52950
39.132	1.52900
41.037	1.52850
42.851	1.52750

Table S14. Refractive indices at 589 nm of a mixture of 5CB + benzyl alcohol ($x_{5CB} = 0.7594$).

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.895	1.58800
20.609	1.58750

Table S14 continued from previous page

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
22.394	1.58650
24.239	1.58550
26.109	1.58450
27.951	1.58375
29.778	1.58300
31.670	1.58200
33.461	1.58125
35.291	1.58050
37.207	1.57950
38.970	1.57875
40.785	1.57800
42.616	1.57700

*S2.2.2. Cinamaldehyde***Table S15.** Refractive indices at 589 nm of cinamaldehyde.

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.878	1.62350
20.624	1.62275
22.485	1.62175
24.361	1.61950
26.163	1.61850
27.999	1.61900
29.849	1.61800
31.715	1.61750
33.494	1.61650
35.355	1.61575
37.207	1.61450
39.029	1.61400
40.868	1.61275
42.755	1.61150

Table S16. Refractive indices at 589 nm of a mixture of 5CB + cinamaldehyde ($x_{5CB} = 0.7948$).

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.699	1.59825
20.500	1.59750
22.339	1.59650
24.195	1.59550
26.056	1.59500
27.890	1.59375

Table S16 continued from previous page

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
29.715	1.59275
31.641	1.59175
33.494	1.59100
35.354	1.59000
37.112	1.58900
38.950	1.58825
40.842	1.58750
42.600	1.58625

*S2.2.3. 1-decanol***Table S17.** Refractive indices at 589 nm of 1-decanol.

Temperature / °C (±0.01)	Refractive index at 589 nm (±0.00001)
20.360	1.43900
22.180	1.43800
24.000	1.43750
25.820	1.43650
27.650	1.43600
29.520	1.43525
31.360	1.43450
33.230	1.43375
35.030	1.43300
36.920	1.43225
38.670	1.43150
40.700	1.43075
39.320	1.43050
41.227	1.42950
43.105	1.42900
44.917	1.42800
46.866	1.42750
48.728	1.42650
50.676	1.42575
52.494	1.42500
54.454	1.42450
56.334	1.42350

Table S18. Refractive indices at 589 nm of a mixture of 5CB + 1-decanol ($x_{5CB} = 0.8689$).

Temperature / °C (±0.01)	Refractive index at 589 nm (±0.00001)
20.43	1.57800
22.24	1.57725

Table S18 continued from previous page

Temperature / °C (±0.01)	Refractive index at 589 nm (±0.00001)
25.83	1.57650
27.71	1.57450
29.48	1.57400
31.42	1.57275
33.18	1.57200
34.92	1.57100
36.78	1.57050
38.62	1.56950
40.36	1.56900

Table S19. Refractive indices at 589 nm of a mixture of MBBA + 1-decanol ($x_{\text{MBBA}} = 0.8435$).

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.453	1.60125
20.312	1.60050
22.213	1.59950
24.213	1.59875
26.045	1.59800
27.927	1.59700
29.838	1.59600
31.742	1.59500
33.648	1.59400
35.544	1.59300
37.424	1.59200
39.334	1.59100
41.233	1.59050
43.052	1.58950
45.043	1.58800
46.875	1.58725
50.613	1.58525
52.604	1.58450
54.351	1.58425
56.347	1.58350

S2.2.4. *Glyceryl trioleate (GTO)*

Table S20. Refractive indices at 589 nm of GTO.

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
20.390	1.46900
22.250	1.46850
24.196	1.46775

Table S20 continued from previous page

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
26.088	1.46700
27.975	1.46675
29.860	1.46575
31.743	1.46500
33.627	1.46450
35.511	1.46350
37.386	1.46300
39.277	1.46200
41.149	1.46125
43.044	1.46050
44.920	1.46000
46.826	1.45900
48.699	1.45850
50.547	1.45775
52.398	1.45725
54.325	1.45625
56.203	1.45550
58.085	1.45500

Table S21. Refractive indices at 589 nm of a mixture of 5CB + GTO ($x_{5CB} = 0.9680$).

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
22.159	1.57875
24.070	1.57800
25.953	1.57700
27.858	1.57625
29.741	1.57500
31.618	1.57400
33.523	1.57325
35.397	1.57225
37.293	1.57125
39.169	1.57050
41.058	1.56975
42.907	1.56900

Table S22. Refractive indices at 589 nm of a mixture of MBBA + GTO ($x_{MBBA} = 0.9544$).

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
20.685	1.59850
22.490	1.59750
24.360	1.59650
26.194	1.59550

Table S22 continued from previous page

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
28.089	1.59450
29.974	1.59350
31.865	1.59275
33.765	1.59150
35.646	1.59050
37.525	1.59000
39.383	1.58900
41.295	1.58800
43.180	1.58700
45.064	1.58650
46.896	1.58500
48.798	1.58475
50.660	1.58375
52.511	1.58300
54.370	1.58225
56.204	1.58100

*S2.2.5. 2,2,4,4,6,8,8-heptamethylnonane (HMN)***Table S23.** Refractive indices at 589 nm of HMN.

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.427	1.44100
20.312	1.44050
22.186	1.43975
24.056	1.43900
25.960	1.43800
27.849	1.43750
29.725	1.43650
31.627	1.43575
33.476	1.43500
35.383	1.43400
37.232	1.43350
39.145	1.43250
41.046	1.43175
41.188	1.43175
43.166	1.43100
45.028	1.43000
47.025	1.42950
48.856	1.42850
50.696	1.42775
52.659	1.42750
54.504	1.42650
56.338	1.42550
58.297	1.42525

Table S24. Refractive indices at 589 nm of a mixture of 5CB + HMN ($x_{5CB} = 0.9138$).

Temperature / °C (± 0.001)	Refractive index at 589 nm (± 0.00001)
18.516	1.58050
20.310	1.57950
22.168	1.57875
24.054	1.57775
25.929	1.57700
27.832	1.57575
29.759	1.57500
31.618	1.57400
33.526	1.57300
35.417	1.57225
37.333	1.57150
39.187	1.57050
41.076	1.57000

Table S25. Refractive indices at 589 nm of a mixture of MBBA + HMN ($x_{MBBA} = 0.8739$).

Temperature / °C (± 0.001)	Refractive index at 589 nm (± 0.00001)
18.587	1.59800
20.427	1.59700
22.288	1.59600
24.195	1.59500
26.098	1.59400
28.019	1.59350
29.903	1.59225
31.804	1.59150
33.687	1.59050
35.573	1.58950
37.450	1.58850
39.352	1.58775
41.155	1.58650
43.112	1.58575
44.972	1.58500
46.942	1.58350
48.734	1.58300
50.607	1.58200
52.604	1.58150
54.501	1.58050
56.409	1.58000
58.142	1.57900
58.297	1.42525

S2.2.6. 1-octanol

Table S26. Refractive indices at 589 nm of 1-octanol.

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.772	1.43100
20.562	1.43000
22.377	1.42950
24.196	1.42900
26.036	1.42800
27.853	1.42725
29.667	1.42650
31.487	1.42550
33.329	1.42500
35.086	1.42400
36.921	1.42350
38.732	1.42250
40.533	1.42100
42.413	1.42050

Table S27. Refractive indices at 589 nm of a mixture of 5CB + 1-octanol ($x_{5CB} = 0.6869$).

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.859	1.55900
20.664	1.55800
22.410	1.55725
24.255	1.55650
26.103	1.55550
27.975	1.55450
29.838	1.55375
31.697	1.55300
33.532	1.55200
35.396	1.55150
37.101	1.55050
38.992	1.54975
40.849	1.54900
42.625	1.54775

S2.2.7. 2-octyl-1-dodecanol (2OD)

Table S28. Refractive indices at 589 nm of 2OD.

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.282	1.45525
20.256	1.45450
22.107	1.45375

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Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
24.038	1.45300
25.955	1.45225
27.774	1.45150
29.621	1.45075
31.538	1.45000
33.445	1.44900
35.401	1.44850
37.319	1.44775
39.236	1.44600
41.034	1.44550
41.257	1.44600
43.207	1.44500
45.082	1.44450
46.953	1.44375
48.893	1.44300
50.794	1.44200
52.703	1.44125
54.571	1.44050
56.426	1.44000
58.237	1.43925

Table S29. Refractive indices at 589 nm of a mixture of 5CB + 2OD ($x_{5CB} = 0.8992$).

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.454	1.57500
20.280	1.57450
22.136	1.57350
24.044	1.57300
25.941	1.57200
27.838	1.57100
29.727	1.57025
31.642	1.56950
33.527	1.56850
35.441	1.56775
37.336	1.56650
39.219	1.56600
41.118	1.56525

Table S30. Refractive indices at 589 nm of a mixture of MBBA + 2OD ($x_{MBBA} = 0.8617$).

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.500	1.59450

Table S30 continued from previous page

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
20.352	1.59400
22.210	1.59275
24.139	1.59200
26.024	1.59100
27.946	1.59050
29.847	1.58925
31.743	1.58825
33.650	1.58725
35.525	1.58625
37.430	1.58550
39.327	1.58450
41.179	1.58350
43.097	1.58275
45.022	1.58150
46.897	1.58050
48.722	1.57975
50.715	1.57875
52.575	1.57800
54.502	1.57700
56.400	1.57600
58.245	1.57525

S2.2.8. 1,1,2,2-tetrabromoethane (TBE)

Table S31. Refractive indices at 589 nm of TBE.

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.870	1.63850
20.618	1.63800
22.386	1.63700
24.187	1.63575
26.025	1.63500
27.841	1.63375
29.666	1.63250
31.484	1.63150
33.274	1.63075
35.074	1.63000
36.915	1.62850
38.718	1.62750
40.537	1.62650
42.302	1.62575

Table S32. Refractive indices at 589 nm of a mixture of 5CB + TBE ($x_{5CB} = 0.7296$).

Temperature / °C (± 0.001)	Refractive index at 589 nm (± 0.00001)
18.818	1.59900
20.674	1.59825
22.483	1.59750
24.340	1.59650
26.175	1.59550
28.054	1.59475
29.860	1.59400
31.725	1.59300
33.599	1.59225
35.479	1.59125
37.302	1.59050
39.064	1.58950
41.034	1.58875
42.693	1.58800

S2.2.9. *n*-undecane

Table S33. Refractive indices at 589 nm of *n*-undecane.

Temperature / °C (± 0.001)	Refractive index at 589 nm (± 0.00001)
19.020	1.41950
21.300	1.41875
23.280	1.41800
25.150	1.41700
26.850	1.41600
28.620	1.41500
30.520	1.41400
32.240	1.41350
34.040	1.41250
35.900	1.41175
37.750	1.41050
39.700	1.41000
41.800	1.40900
44.000	1.40850

Table S34. Refractive indices at 589 nm of a mixture of 5CB + *n*-undecane ($x_{5CB} = 0.8471$).

Temperature / °C (± 0.001)	Refractive index at 589 nm (± 0.00001)
20.460	1.57150
22.200	1.57100
24.070	1.57000

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Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
25.820	1.56950
27.610	1.56850
29.570	1.56700
31.300	1.56625
33.100	1.56500
34.950	1.56450
36.720	1.56350
38.480	1.56300
40.220	1.56200

*S2.2.10. 1-undecanol***Table S35.** Refractive indices at 589 nm of 1-undecanol.

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.791	1.44200
20.705	1.44150
22.470	1.44100
24.295	1.44025
26.146	1.43950
27.948	1.43900
29.764	1.43800
31.620	1.43750
33.480	1.43650
35.324	1.43575
37.108	1.43500
38.954	1.43400
40.761	1.43350
42.583	1.43275

Table S36. Refractive indices at 589 nm of a mixture of 5CB + 1-undecanol ($x_{5CB} = 0.8261$).

Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
18.930	1.57150
20.704	1.57100
22.531	1.57000
24.295	1.56900
26.147	1.56825
27.988	1.56700
29.829	1.56600
31.692	1.56550
33.556	1.56425

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Temperature / °C (±0.001)	Refractive index at 589 nm (±0.00001)
35.352	1.56350
37.210	1.56250
39.045	1.56150
40.820	1.56075
42.718	1.56000