Supplementary materials

As shown in Fig.S1, the pulse emitted by the femtosecond laser is divided into a detection pulse and a pump pulse by a beam splitter. The pump pulse generates a THz pulse via a photoconductive antenna, the THz pulse perpendicular incident on the sample after collimated by off-axis parabolic mirrors, and the THz pulse carrying on sample information is refocused by off-axis parabolic mirrors and incident on the photoelectric crystal. The detection pulse modulated by Terahertz pulse is converted into an electrical signal by a photodiode, amplified by a lock-in amplifier, and input to a computer for data processing.

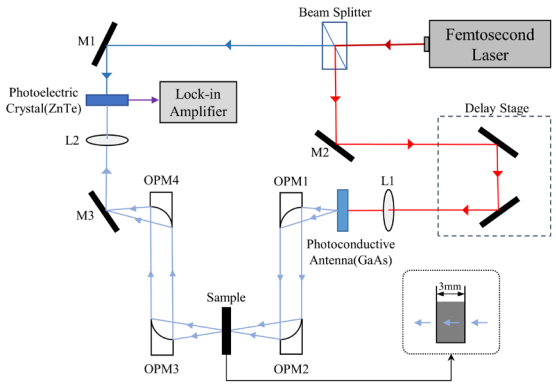


Figure S1. Schematic diagram of transmission THz-TDS setup. M1, M2, and M3 are reflectors, L1 and L2 are lenses, and OPM1, OPM2, OPM3, and OPM4 are off-axis parabolic mirrors.

Table S1. Country, name, and number of crude oil samples.

Country[a]	Sample name[b]	Sample number	Sample name[b]	Sample number
Angola (15)	SATURNO BLEND1	Angola1	SATURNO BLEND2	Angola2
	KISSANJE1	Angola3	KISSANJE2	Angola4
	KISSANJE3	Angola5	KISSANJE4	Angola6

	CLOV1	Angola7	CLOV2	Angola8
	CABINBA	Angola9	PLUTONIO1	Angola10
	PLUTONIO2	Angola11	MEMBA	Angola12
	OLOMBEN DO	Angola13	GINDUNGO	Angola14
	HUNGO	Angola15		
Brazil （24）	LAPA1	Brazil1	LAPA2	Brazil2
	SAPINHOA1	Brazil3	SAPINHOA2	Brazil4
	SAPINHOA3	Brazil5	SAPINHOA4	Brazil6
	SAPINHOA5	Brazil7	TUPI1	Brazil8
	TUPI2	Brazil9	TUPI3	Brazil10
	TUPI4	Brazil11	TUPI5	Brazil12
	BUZIOS1	Brazil13	BUZIOS2	Brazil14
	BUZIOS3	Brazil15	IRACEMA1	Brazil16
	IRACEMA2	Brazil17	IRACEMA3	Brazil18
	IRACEMA4	Brazil19	LULA1	Brazil20
	LULA2	Brazil21	LULA3	Brazil22
	LULA4	Brazil23	SURURU	Brazil24
Saudi Arabia （10）	ARABIAN MEDIUM1	Saudi-Arabia1	ARABIAN MEDIUM2	Saudi-Arabia2
	ARABIAN MEDIUM3	Saudi-Arabia3	ARABIAN HEAVY1	Saudi-Arabia4

	ARABIAN HEAVY2	Saudi-Arabia5	ARABIAN HEAVY3	Saudi-Arabia6
	ARABIAN LIGHT1	Saudi-Arabia7	ARABIAN LIGHT2	Saudi-Arabia8
	ARABIAN LIGHT3	Saudi-Arabia9	ARABIAN LIGHT4	Saudi-Arabia10
Russia （19）	ESPO1	Russia1	ESPO2	Russia2
	ESPO3	Russia3	ESPO4	Russia4
	ESPO5	Russia5	ESPO6	Russia6
	ESPO7	Russia7	ESPO8	Russia8
	ESPO9	Russia9	ESPO10	Russia10
	ESPO11	Russia11	ESPO12	Russia12
	ESPO13	Russia13	ESPO14	Russia14
	ESPO15	Russia15	ESPO16	Russia16
	SOKOL1	Russia17	SOKOL2	Russia18
	SOKOL3	Russia19		
The Republic of Congo （8）	DJENO1	Congo1	DJENO2	Congo2
	DJENO3	Congo3	DJENO4	Congo4
	DJENO5	Congo5	DJENO6	Congo6
	DJENO7	Congo7	DJENO8	Congo8
Iran （7）	IRANIAN HEAVY1	Iran1	IRANIAN HEAVY2	Iran2

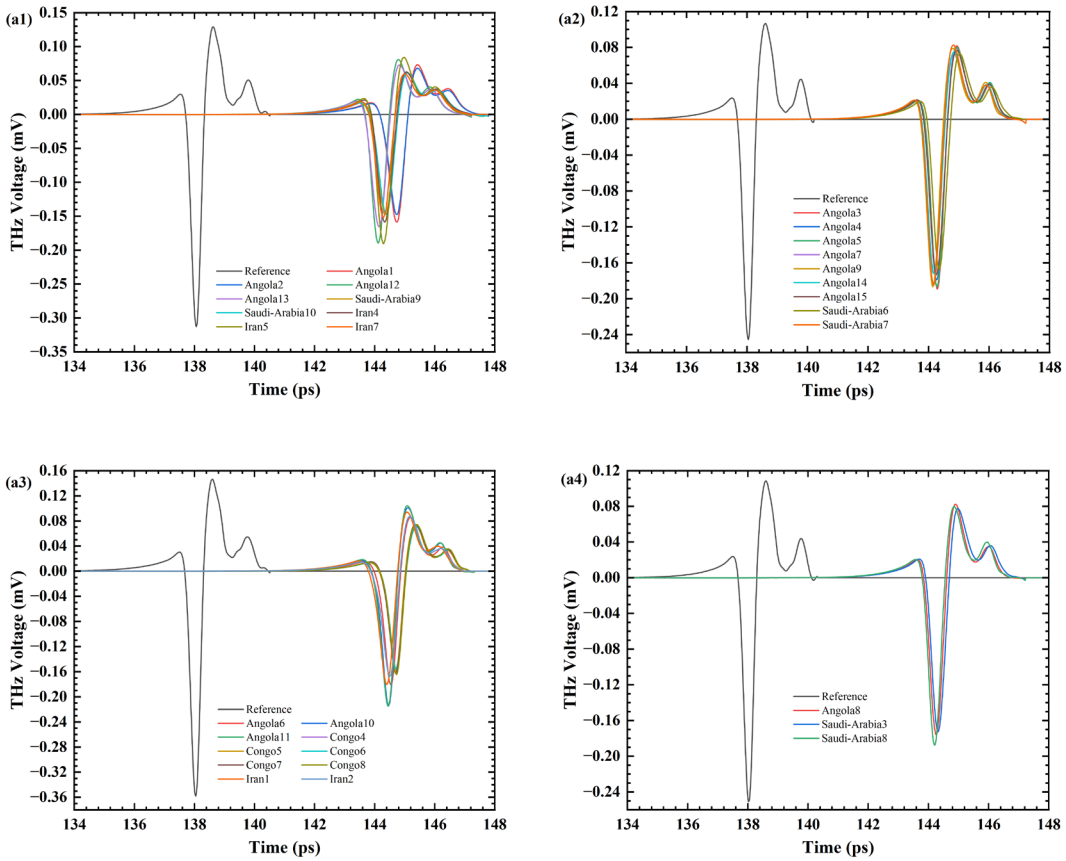
	SIRRI1	Iran3	SIRRI2	Iran4
	IRANIAN LIGHT1	Iran5	IRANIAN LIGHT2	Iran6
	IRANIAN LIGHT3	Iran7		

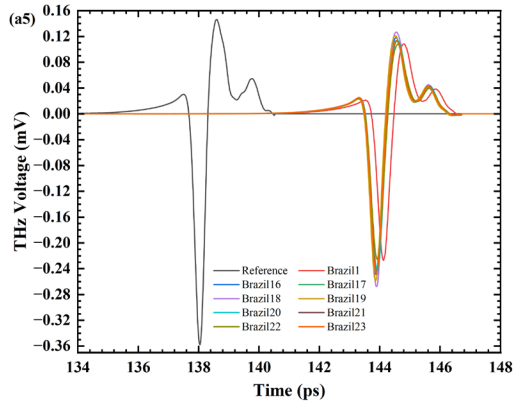
[a] the numbers in brackets represent the number of samples.

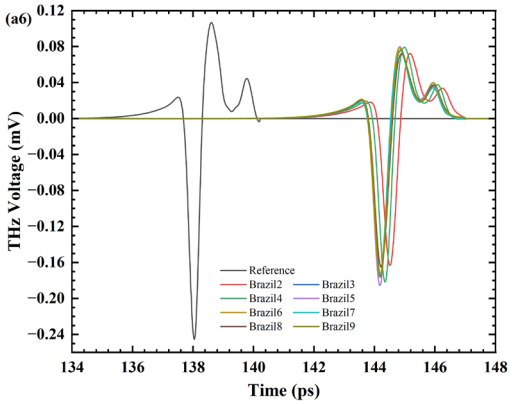
[b] the sample names represent the port/variety/pipeline/oilfield of the crude oil source, and the suffix numbers represent different batches of imported crude oil.

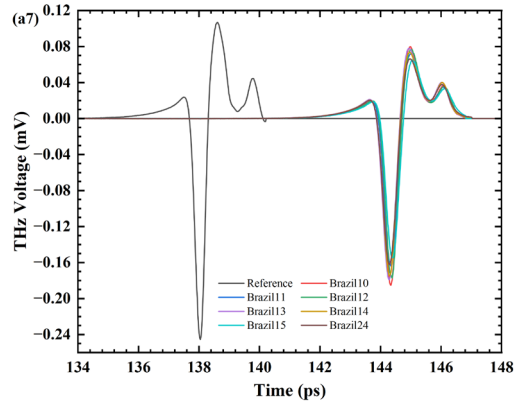
(The crude oil samples used in this experiment are provided by Qingdao Customs Technical Center)

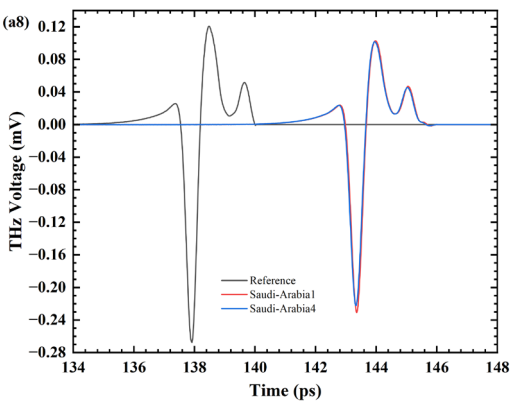
To provide an intuitive understanding of the crude oil classification issue discussed in the main text, we present the spectral information of all 83 crude oil samples, as shown in Fig. S2.

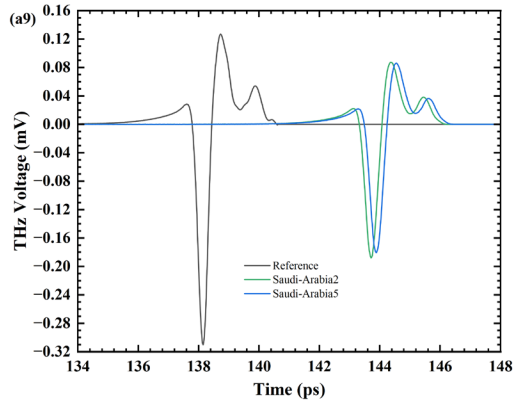


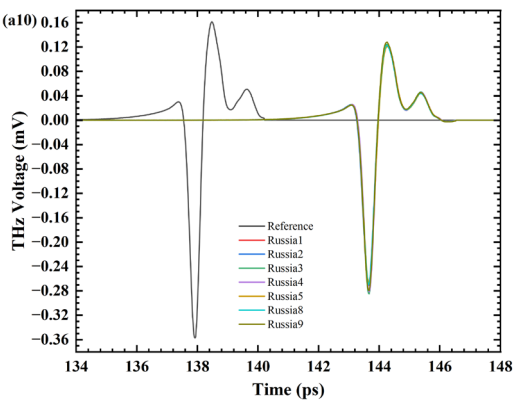

(a5)
THz Voltage (mV)
Time (ps)
Reference
Brazil1
Brazil16
Brazil17
Brazil18
Brazil19
Brazil20
Brazil21
Brazil22
Brazil23

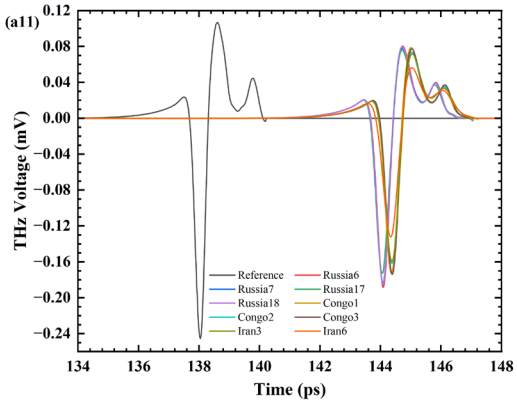

(a6)
THz Voltage (mV)
Time (ps)
Reference
Brazil2
Brazil3
Brazil4
Brazil5
Brazil6
Brazil7
Brazil8
Brazil9

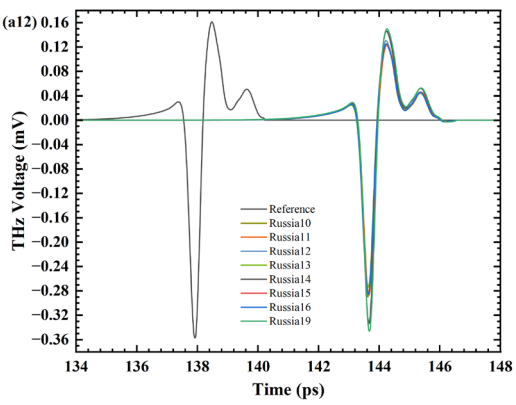

(a7)
THz Voltage (mV)
Time (ps)
Reference
Brazil10
Brazil11
Brazil12
Brazil13
Brazil14
Brazil15
Brazil24

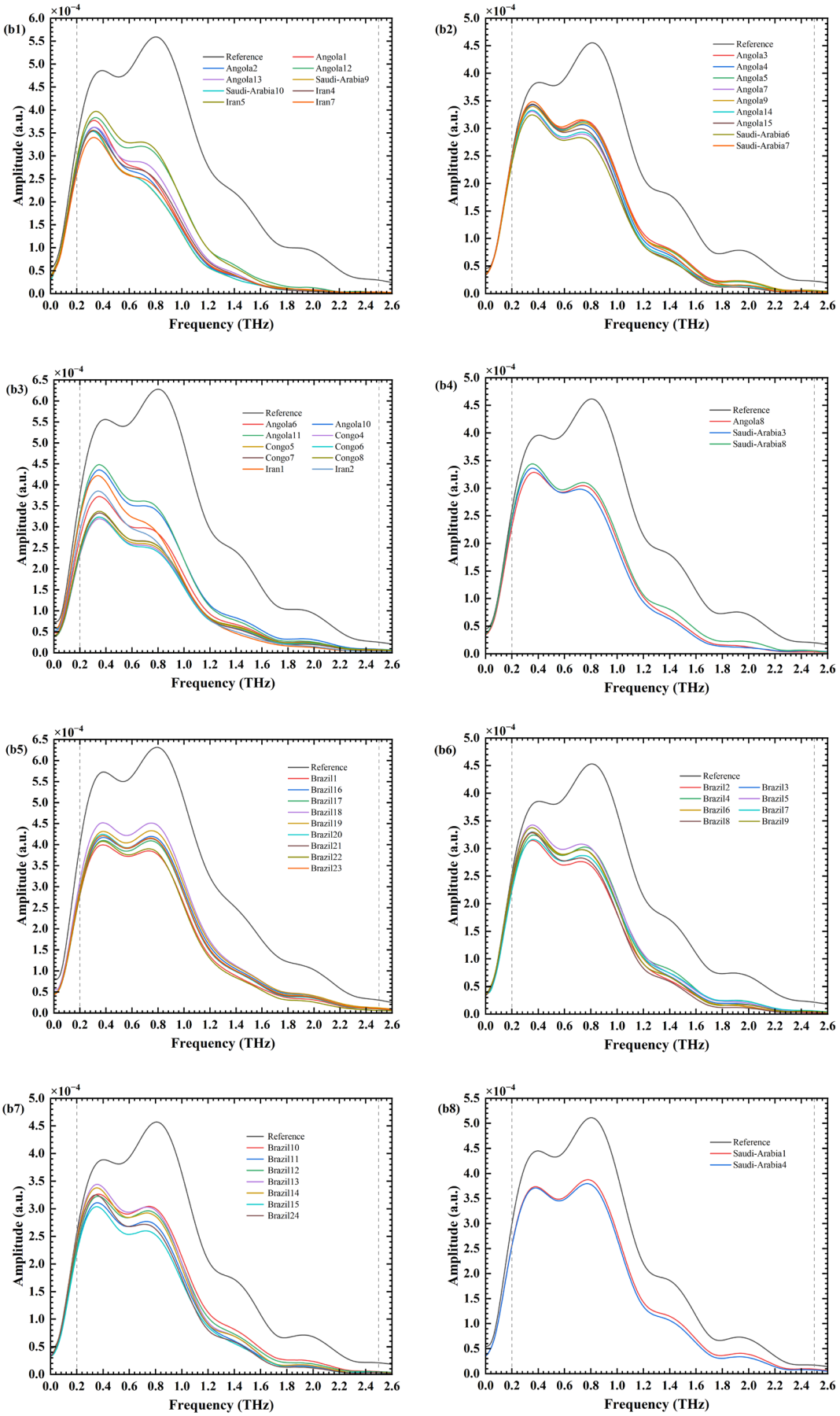

(a8)
THz Voltage (mV)
Time (ps)
Reference
Saudi-Arabia1
Saudi-Arabia4


(a9)
THz Voltage (mV)
Time (ps)
Reference
Saudi-Arabia2
Saudi-Arabia5


(a10)
THz Voltage (mV)
Time (ps)
Reference
Russia1
Russia2
Russia3
Russia4
Russia5
Russia8
Russia9


(a11)
THz Voltage (mV)
Time (ps)
Reference
Russia6
Russia7
Russia17
Russia18
Congo1
Congo2
Congo3
Iran3
Iran6


(a12)
THz Voltage (mV)
Time (ps)
Reference
Russia10
Russia11
Russia12
Russia13
Russia14
Russia15
Russia16
Russia19


(b1)
×10⁻⁴
Amplitude (a.u.)
Frequency (THz)
Reference
Angola1
Angola2
Angola12
Angola13
Saudi-Arabia9
Saudi-Arabia10
Iran4
Iran5
Iran7
(b2)
Reference
Angola3
Angola4
Angola5
Angola7
Angola9
Angola14
Angola15
Saudi-Arabia6
Saudi-Arabia7
(b3)
Reference
Angola6
Angola10
Angola11
Congo4
Congo5
Congo6
Congo7
Congo8
Iran1
Iran2
(b4)
Reference
Angola8
Saudi-Arabia3
Saudi-Arabia8
(b5)
Reference
Brazil1
Brazil16
Brazil17
Brazil18
Brazil19
Brazil20
Brazil21
Brazil22
Brazil23
(b6)
Reference
Brazil2
Brazil3
Brazil4
Brazil5
Brazil6
Brazil7
Brazil8
Brazil9
(b7)
Reference
Brazil10
Brazil11
Brazil12
Brazil13
Brazil14
Brazil15
Brazil24
(b8)
Reference
Saudi-Arabia1
Saudi-Arabia4

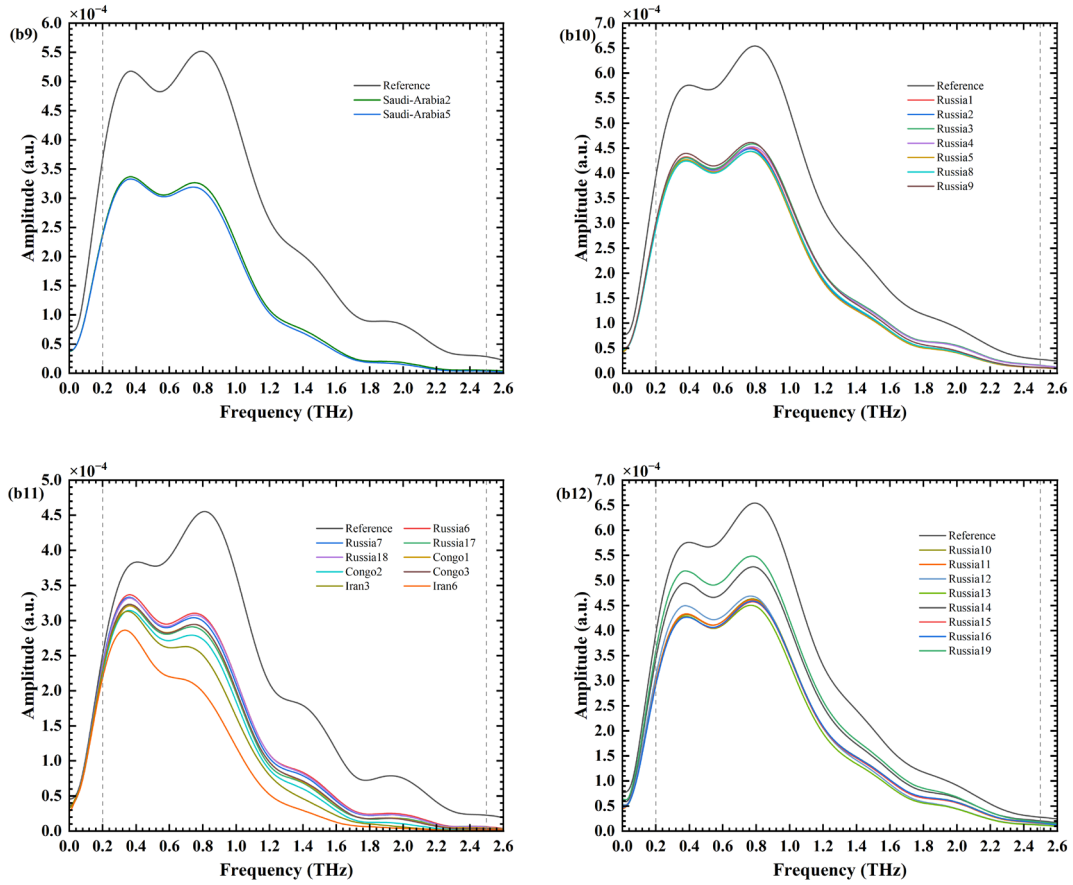
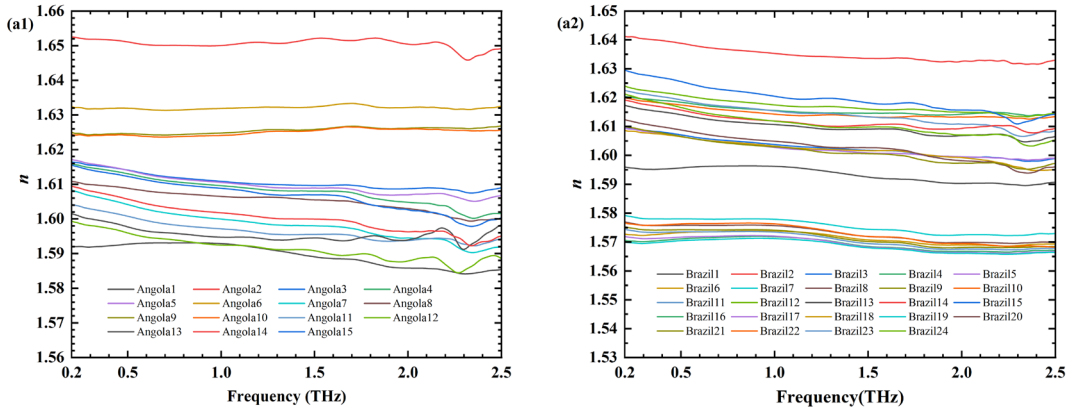
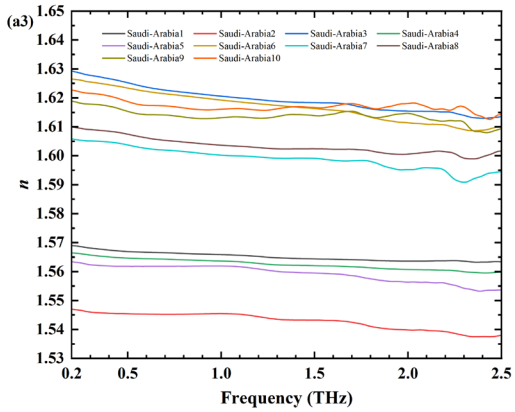
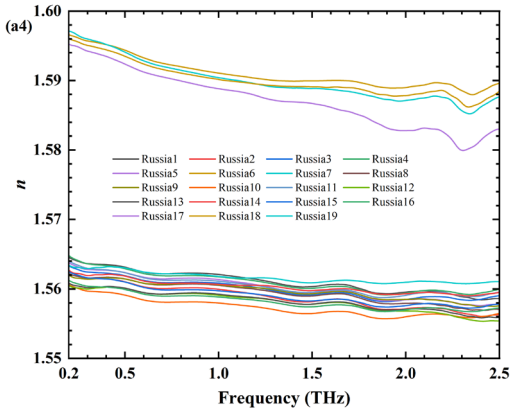


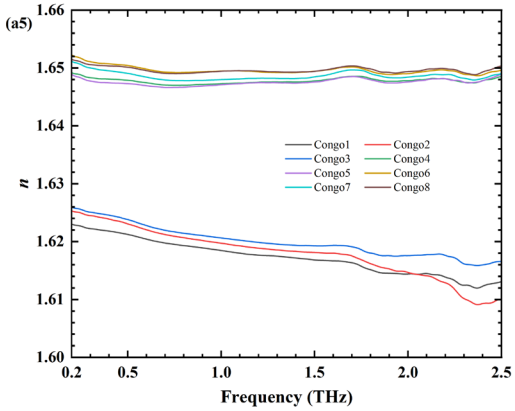
Figure S2. (a1) - (a12) are THz time-domain spectra of crude oils; (b1) - (b12) are THz frequency-domain spectra of crude oils.

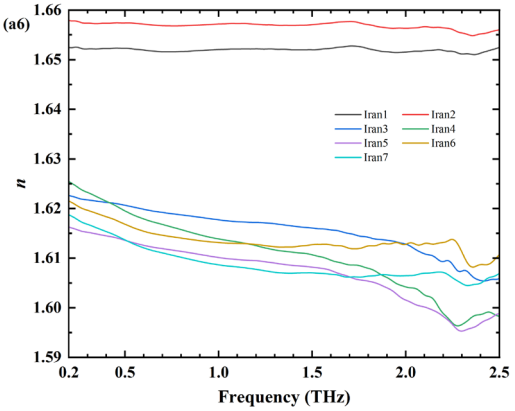
Fig. S3 shows the refractive index spectra and absorption coefficient spectra of all the crude oils described in the main text.

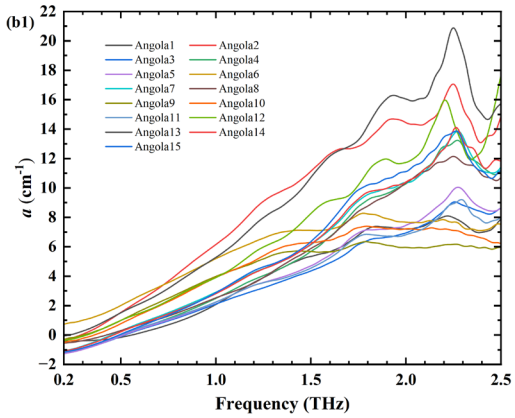


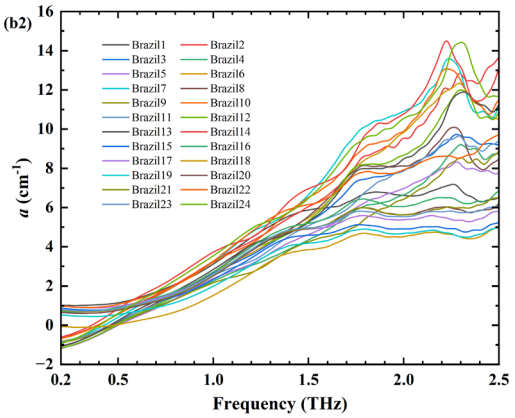

(a3)
Saudi-Arabia1
Saudi-Arabia2
Saudi-Arabia3
Saudi-Arabia4
Saudi-Arabia5
Saudi-Arabia6
Saudi-Arabia7
Saudi-Arabia8
Saudi-Arabia9
Saudi-Arabia10
n
Frequency (THz)

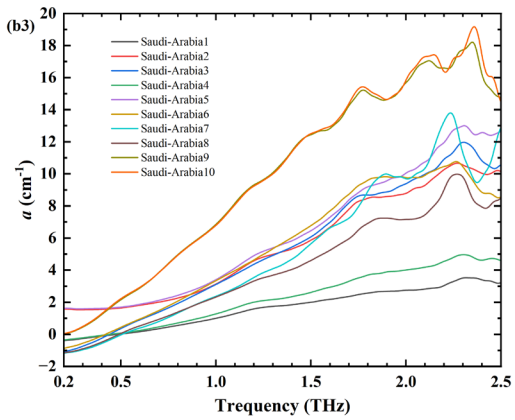

(a4)
Russia1
Russia2
Russia3
Russia4
Russia5
Russia6
Russia7
Russia8
Russia9
Russia10
Russia11
Russia12
Russia13
Russia14
Russia15
Russia16
Russia17
Russia18
Russia19
n
Frequency (THz)

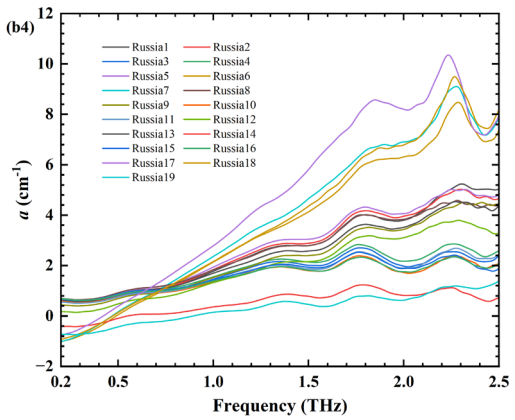

(a5)
Congo1
Congo2
Congo3
Congo4
Congo5
Congo6
Congo7
Congo8
n
Frequency (THz)


(a6)
Iran1
Iran2
Iran3
Iran4
Iran5
Iran6
Iran7
n
Frequency (THz)


(b1)
Angola1
Angola2
Angola3
Angola4
Angola5
Angola6
Angola7
Angola8
Angola9
Angola10
Angola11
Angola12
Angola13
Angola14
Angola15
a (cm-1)
Frequency (THz)


(b2)
Brazil1
Brazil2
Brazil3
Brazil4
Brazil5
Brazil6
Brazil7
Brazil8
Brazil9
Brazil10
Brazil11
Brazil12
Brazil13
Brazil14
Brazil15
Brazil16
Brazil17
Brazil18
Brazil19
Brazil20
Brazil21
Brazil22
Brazil23
Brazil24
a (cm-1)
Frequency (THz)


(b3)
Saudi-Arabia1
Saudi-Arabia2
Saudi-Arabia3
Saudi-Arabia4
Saudi-Arabia5
Saudi-Arabia6
Saudi-Arabia7
Saudi-Arabia8
Saudi-Arabia9
Saudi-Arabia10
a (cm-1)
Frequency (THz)


(b4)
Russia1
Russia2
Russia3
Russia4
Russia5
Russia6
Russia7
Russia8
Russia9
Russia10
Russia11
Russia12
Russia13
Russia14
Russia15
Russia16
Russia17
Russia18
Russia19
a (cm-1)
Frequency (THz)

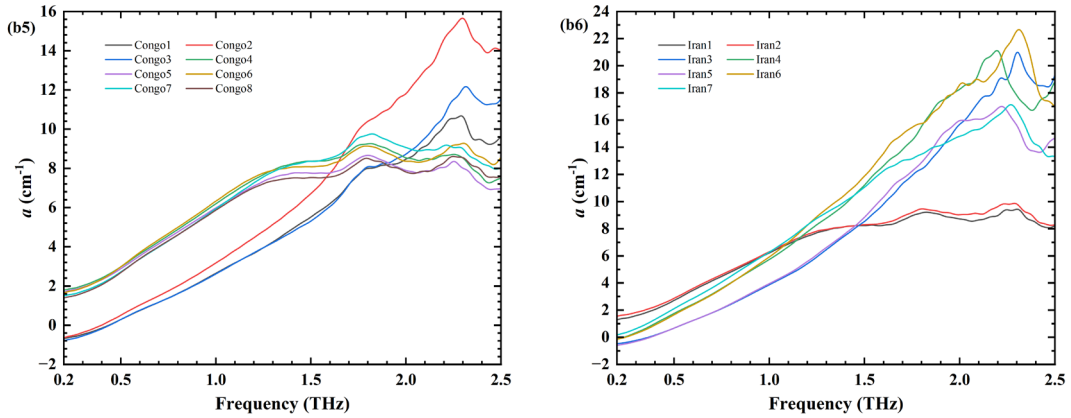


Figure S3. (a1) - (a6) are the refractive index spectra of crude oil; (b1) - (b6) are the absorption coefficient spectra of crude oil.