Support Information for

Visbreaking of Heavy Oil in Supercritical Benzene

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Table S1. Chemical Shift of H Atoms Relating to Olefins Contained in Oil Samples

H atom type	chemical shift (ppm)	number of H atoms
-CR=CH_2	4.5-4.7	2
-CH=CH_2	4.7-5.0	3
-CR=CH-	5.0-5.2	1
-CH=CH-	5.2-5.5	2

Table S2. Equations Adopted in Modified Brown-Ladner Method for Determining Average Molecular Structure Parameters of Raw Heavy Oil or Liquid Products

parameter	equation	parameter	equation
M_n	from VPO	f	$12\times n/(2\times n+1-2\times r)$
β，γ	from ^{1}H-NMR	BI	γ/β
H/C	H%×12/C%	C_S	$f\times(H_\alpha+H_\beta+H_\gamma)\times H\%/100$
n	$(H_\alpha+H_\beta+H_\gamma)/H_\alpha$	C_A	$C\%-C_S$
r	$(0.25\times(BI+4.12)-1)/2\times(n-1)$	C_1	$(12\times H_{aro}+f\times H_\alpha)\times H\%/100$
R_A	$(\#C_A-\#C_1)/2+1$	$\#C_1$	$C_1\times Mn/1200$
R_N	$\%AS\times C_1\times r/100$	%AS	$f\times H_\alpha\times H\%/C_1$
R_S	$\%AS\times\#C_1/100$	$\#C_A$	$C_A\times M_n/1200$

Nomenclature

M_n = number average molecular weight of oil samples, Da
C% = weight percentage of carbon, wt%
H% = weight percentage of hydrogen, wt%
H_α = aliphatic hydrogen α to aromatic ring with chemical shift of 2.0-4.5 ppm
H_β = aliphatic hydrogen β or further from aromatic ring with chemical shift of 1.05-2.0 ppm
H_γ = methyl hydrogen γ or further from aromatic ring with chemical shift of 0.5-1.05 ppm
H_{aro} = aromatic hydrogen with chemical shift of 6.0-9.0 ppm
γ, β = peak height of H_γ or H_β from ^{1}H-NMR
BI = branchiness index.
H/C = H/C atomic ratio
n = average carbon number of alkyl substituents
r = number of naphthene rings per substituent
f = average C/H weight ratio of alkyl groups.
C_S = fraction of non-aromatic C atoms in total C atoms contained in oil samples, %
C_A = fraction of aromatic C atoms in total C atoms contained in oil samples, %
C_1 = fraction of non-bridge aromatic ring carbons
$\#C_1$ = average number of non-bridge aromatic ring carbon atoms per average molecule
%AS = percent substitution of alkyl groups on non-bridge aromatic ring carbons
$\#C_A$ = average number of aromatic ring carbon atoms per average molecule.
R_A = average number of aromatic rings per average molecule
R_N = average number of naphthenic rings per average molecule
R_S = average number of alkyl substituents per average molecule