

Supporting Information

Halogen- free ammonium- organoborate ionic liquids as lubricating additives: effect of alkyl chain lengths on the tribological performance

Praveen K. Khatri,^a Chetan Joshi,^a Gananath D. Thakre^{b*} and Suman L. Jain^{a*}

^aChemical Sciences Division, CSIR-Indian Institute of Petroleum, Mohkampur, Dehradun-248005

^bTribology & Combustion Division, CSIR-Indian Institute of Petroleum, Mohkampur, Dehradun-248005 (India)

*Email: suman@iip.res.in; gdthakre@iip.res.in

Characterization of ammonium organoborate ionic liquids

Table S1: Elemental analysis data of synthesized ionic liquids

Ionic liquid	C (% wt)	H(% wt)	N(% wt)
[N4444] MAB]	57.73 (57.77)	8.87 (8.82)	3.01 (3.06)
[N4444] [SAB]	59.22 (59.38)	9.11 (9.14)	2.92 (2.89)
[N4444] [GAB]	61.08 (60.82)	9.36 (9.42)	2.76 (2.73)
[N4444] [AAB]	62.14 (62.10)	9.84 (9.68)	2.48 (2.59)

*values in parenthesis are calculated values

Table S2: ¹H NMR data of synthesized ionic liquids

Ionic liquid	Physical Appearance	Yield (%)	¹ H NMR data (ppm)	¹³ C NMR data (ppm)
[N4444] [MAB]	viscous pale yellow liquid	95	0.99(t, CH ₃), 1.46 (sex, CH ₃ CH ₂), 1.65 (quin, CH ₃ CH ₂ CH ₂), 3.3 (t, -CH ₂ N), 3.52 (s, -COCH ₂ CO)	13.69 (CH ₃), 19.73 (CH ₃ CH ₂), 24.07 (CH ₃ CH ₂ CH ₂), 39.20 (-COCH ₂ CO), 58.95 (CH ₂ N), 174.88 (C=O)
[N4444] [SAB]	viscous colourless liquid	97	1.01(t, CH ₃), 1.46 (sex, CH ₃ CH ₂), 1.68 (quin, CH ₃ CH ₂ CH ₂), 3.36 (t, -CH ₂ N), 2.585 (s, -COCH ₂ CH ₂ CO)	13.74 (CH ₃), 19.76(CH ₃ CH ₂), 24.17 (CH ₃ CH ₂ CH ₂), 36.20 (-COCH ₂ CH ₂ CO), 59.00 (CH ₂ N), 175.11(C=O)
[N4444] [GAB]	viscous colourless liquid	96	1.00(t, CH ₃), 1.45 (sex, CH ₃ CH ₂), 1.67 (quin, CH ₃ CH ₂ CH ₂ +COCH ₂ CH ₂ CH ₂ CO), 3.33 (t, -CH ₂ N), 2.45 (t, -COCH ₂ CH ₂ CH ₂ CO)	13.70 (CH ₃), 19.73(CH ₃ CH ₂), 19.91 (COCH ₂ CH ₂ CH ₂ CO)24.07 (CH ₃ CH ₂ CH ₂), 33.22 (-COCH ₂ CH ₂ CH ₂ CO), 58.93 (CH ₂ N), 176.87(C=O)
[N4444] [AAB]	viscous colourless liquid	94	1.01(t, CH ₃), 1.45 (sex, CH ₃ CH ₂), 1.69 (quin, CH ₃ CH ₂ CH ₂ +COCH ₂ CH ₂ CH ₂ CH ₂ CO), 3.37 (t, -CH ₂ N), 2.41 (t, -COCH ₂ (CH ₂) ₂ CH ₂ CO)	13.74 (CH ₃), 19.78(CH ₃ CH ₂), 24.19 (CH ₃ CH ₂ CH ₂), 24.52 (COCH ₂ CH ₂ CH ₂ CH ₂ CO) 34.49 (-COCH ₂ CH ₂ CH ₂ CH ₂ CO), 59.05 (CH ₂ N), 175.88(C=O)

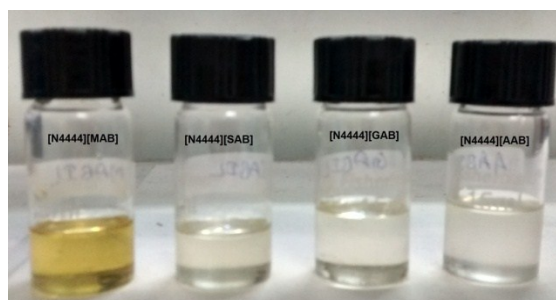
**Figure S1: Physical appearance of the synthesized ILs**

Fig. S2-S5: DSC patterns of synthesized organoborate ionic liquids

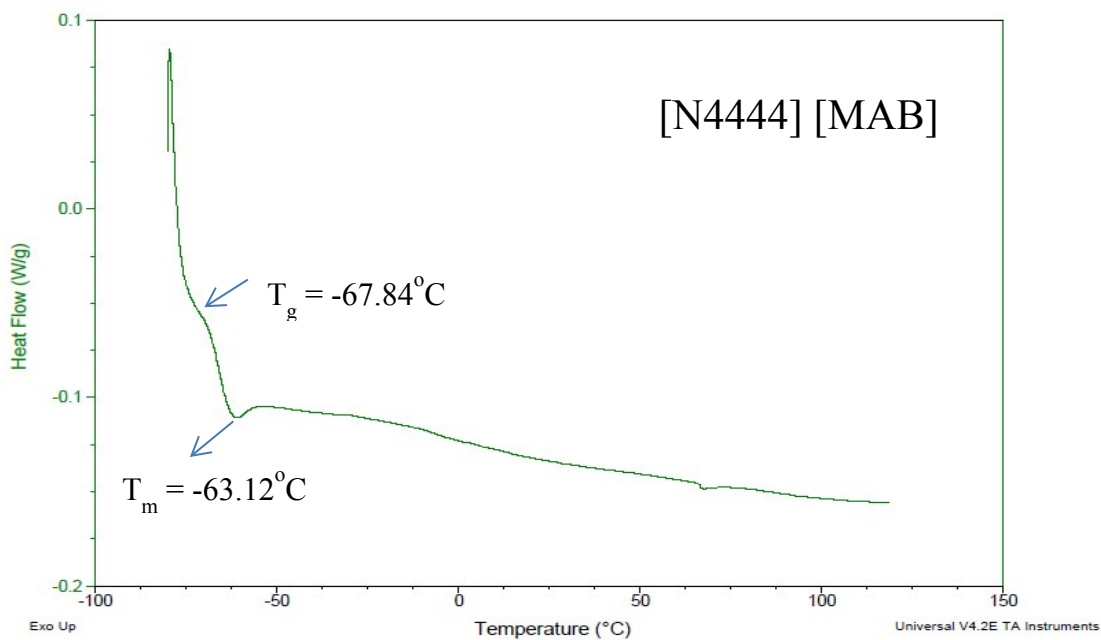


Fig. S2: DSC curve of ionic liquid [N4444][MAB]

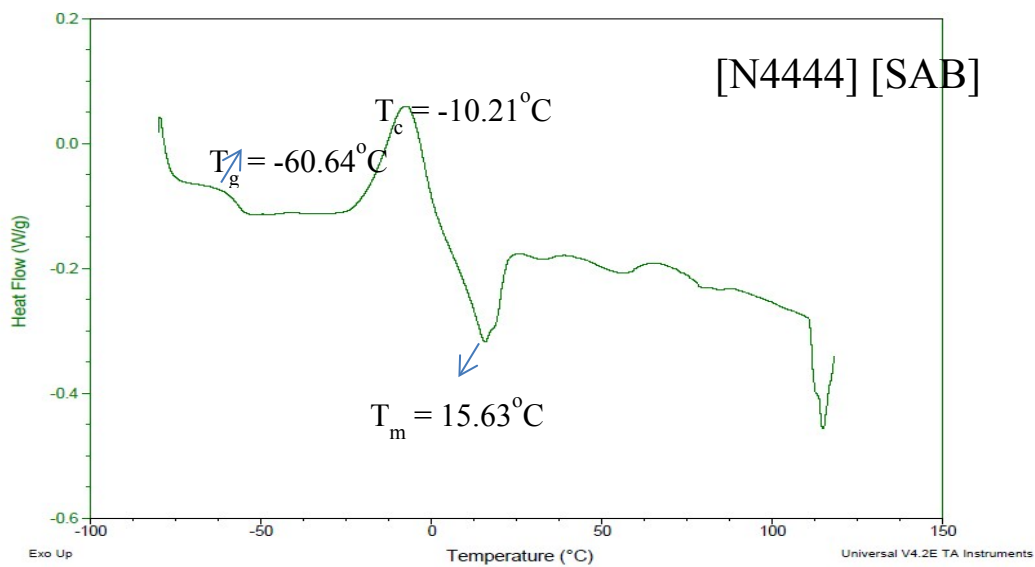


Fig. S3: DSC curve of ionic liquid [N4444][SAB]

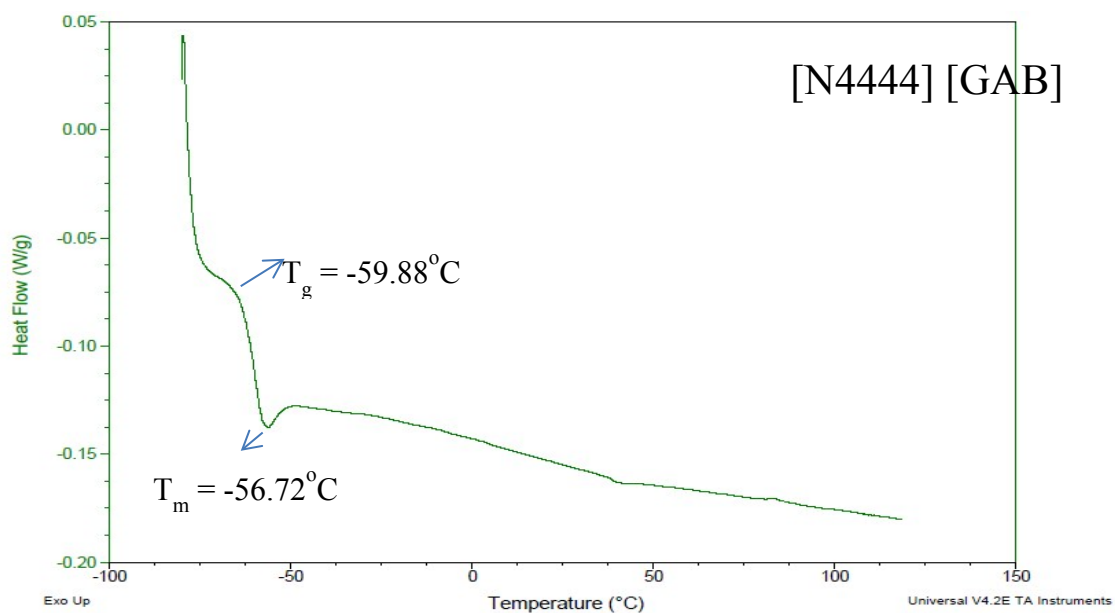


Fig. S4: DSC curve of ionic liquid [N4444][GAB]

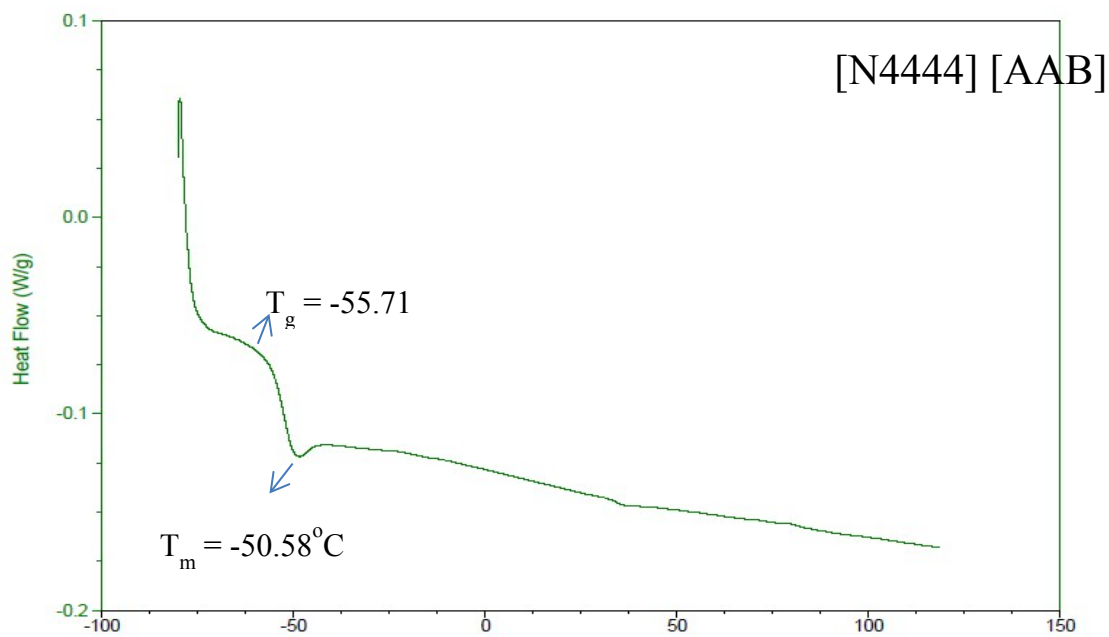


Fig. S5: DSC curve of ionic liquid [N4444][AAB]