Supporting Information

Ionic liquid functionalized binary montmorillonite nanomaterials as water-based lubricant additives for steel/steel contact

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S1. The synthetic route of alkanolamine-phosphate PIL and DBU-unsaturated fatty acid PIL.

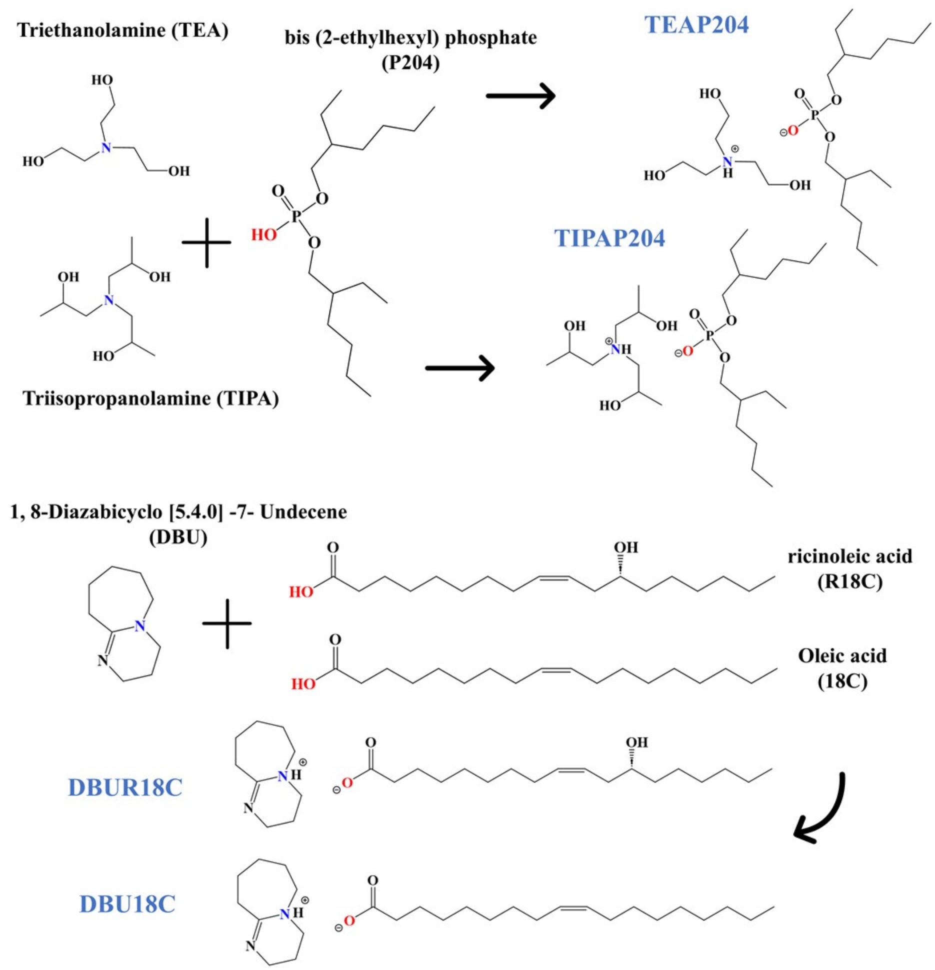

Figure S1. The synthetic route of alkanolamine-phosphate PIL and DBU-unsaturated fatty acid PIL.

The alkanolamine-phosphate PIL was made by proton transfer reactions. To a 250 mL three-necked flask, 19.1 g of triisopropanolamine or 14.9 g of triethanolamine, and 32.2 g bis (2-ethylhexyl) phosphate were added, then consequent mixture was allowed to stir in 50 ml acetonitrile solvent at 80°C for 12 h. After reaction, the product was collected using rotary evaporator and was vacuum-dried for 24 hours to remove the solvent. The synthesis of 1, 8-Diazabicyclo [5.4.0] -7- Undecene (DBU)-unsaturated fatty acid PIL follows a process similar to that of alkanolamine-phosphate PIL, involving proton transfer between DBU and oleic acid or DBU and ricinoleic acid. And the molar ratio of their reaction is 1:1. As shown in Figure S1, according to the different raw materials, the PIL are named TEAP204, TIPAP204, DBU18C and DBUR18C, respectively.

S2. The Fourier transform infrared spectroscopy (FTIR) of PIL.

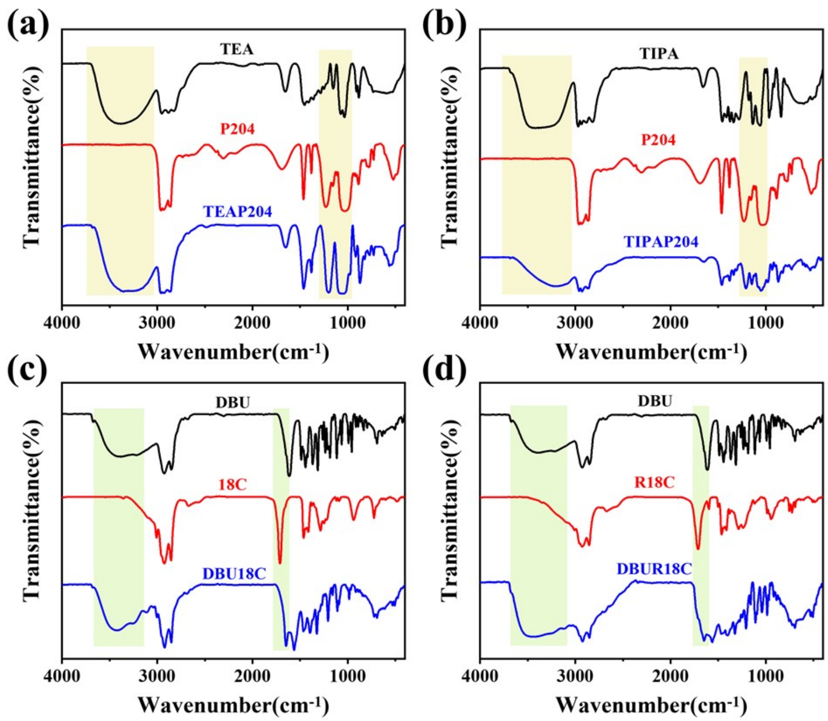

Figure S2. FT-IR spectra of (a) TEAP204, (b) TIPAP204, (c) DBU18C and (d) DBUR18C.

The FT-IR spectrum of alcoholamine-phosphate PIL is illustrated in Figure S2a, b. It is noteworthy that the broad peak at 3400 cm^{-1} corresponds to the stretching vibrations of N-H and O-H. Additionally, the peaks at 1209 cm^{-1} and 1043 cm^{-1} indicate the presence of P=O and P-O stretching bands, which serve as confirmation for the successful synthesis of the ionic liquid.

Meanwhile, the IR spectrum of DBU-unsaturated fatty acid PIL is depicted in Figure S2c, d, showing a broad peak at 3350 cm^{-1} corresponding to the stretching vibration of

N-H bonds. Additionally, a distinctive peak at 1651 cm^{-1} indicative of the carbon-carbon double bond specific to oleic acid and ricinoleic acid was observed. The alterations in the IR spectrum validate the successful preparation of DBU-unsaturated fatty acid PIL.

S3. Comparison of tribological properties with Polyethylene Glycol 200 (PEG-200).

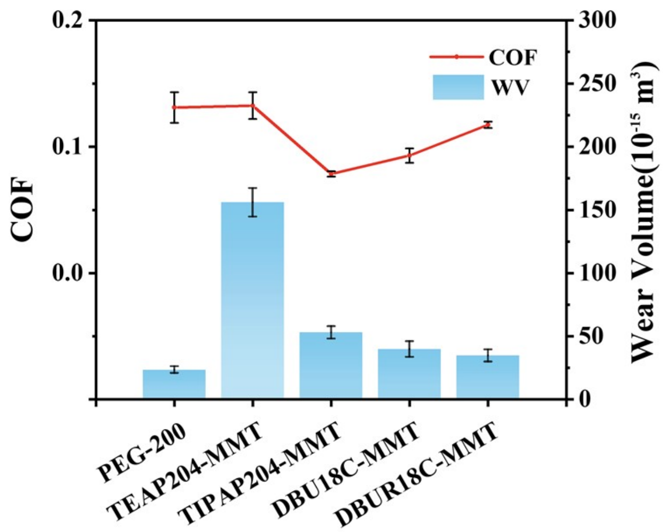

Figure S3. Average COF and WV following lubrication with PEG-200, TEAP204-MMT, TIPAP204-MMT, DBU18C-MMT and DBUR18C-MMT.

The friction coefficients (COF) and wear volumes (WV) of four lubricant samples with an additive concentration of 1.5% after undergoing friction tests under the same test conditions with PEG-200 are depicted in Figure S3. As a widely employed lubricant, the COF of PEG-200 amounts to 0.13, and the WV reaches 23.5×10^{-15} m^3. By contrast, the COF of the lubricant prepared in this research is lower; however, the WV after lubrication is marginally higher than that of PEG-200.