Effect of Ion Structure on Nanoscale Friction in Protic Ionic Liquids

James Sweeney\textsuperscript{1}, Grant B. Webber\textsuperscript{1}, Mark W. Rutland\textsuperscript{2,3}, Rob Atkin\textsuperscript{1,*}

\textsuperscript{1}Centre for Advanced Particle Processing and Transport, Newcastle Institute for Energy and Resources, The University of Newcastle, Callaghan, NSW 2308, Australia

\textsuperscript{2}Surface and Corrosion Science, Department of Chemistry, Royal Institute of Technology, SE-100 44 Stockholm, Sweden

\textsuperscript{3}SP Technical Research Institute of Sweden, Stockholm, Sweden

* To whom correspondence should be addressed.

Email: rob.atkin@newcastle.edu.au

Supporting Information

Figures

\textbf{Figure A.} Force as a function of apparent separation for a \( \approx 5 \) \( \mu \)m diameter silica colloid probe approaching (blue diamonds) and retracting from (red diamonds) a mica surface in EAN. Forces are normalised by \( 2\pi R \), where \( R \) is the radius of the colloid probe.
**Figure B.** Force as a function of apparent separation for a $\approx 5 \, \mu\text{m}$ diameter silica colloid probe approaching (blue diamonds) and retracting from (red diamonds) a mica surface in PAN. Forces are normalised by $2\pi R$, where $R$ is the radius of the colloid probe.

**Figure C.** Force as a function of apparent separation for a $\approx 5 \, \mu\text{m}$ diameter silica colloid probe approaching (blue diamonds) and retracting from (red diamonds) a mica surface in EAF. Forces are normalised by $2\pi R$, where $R$ is the radius of the colloid probe.
Figure D. Force as a function of apparent separation for a $\approx 5 \ \mu$m diameter silica colloid probe approaching (blue diamonds) and retracting from (red diamonds) a mica surface in PAF. Forces are normalised by $2\pi R$, where $R$ is the radius of the colloid probe.

Figure E. Force as a function of apparent separation for a $\approx 5 \ \mu$m diameter silica colloid probe approaching (blue diamonds) and retracting from (red diamonds) a mica surface in DMEAF. Forces are normalised by $2\pi R$, where $R$ is the radius of the colloid probe.
**Figure F.** Force as a function of apparent separation for a $\approx 5 \, \mu m$ diameter silica colloid probe approaching (blue diamonds) and retracting from (red diamonds) a mica surface in EtAN. Forces are normalised by $2\pi R$, where $R$ is the radius of the colloid probe.

**Figure G.** Shear force as a function of normal load at a sliding velocity of $30 \, \mu m \cdot s^{-1}$ for each IL in this study. The shear force presented is the average of at least three normalised datasets taken with the same cantilever/colloidal probe combination. Squares: PAF, diamonds: PAN, triangles: EtAN, stars: EAN, circles: EAF, crosses: DMEAF. Forces are normalised by $2\pi R$, where $R$ is the radius of the colloid probe.
Figure H. Shear force as a function of normal load at a sliding velocity of 20 $\mu$m·s$^{-1}$ for each IL in this study. The shear force presented is the average of at least three normalised datasets taken with the same cantilever/colloidal probe combination. Squares: PAF, diamonds: PAN, triangles: EtAN, stars: EAN, circles: EAF, crosses: DMEAF. Forces are normalised by $2\pi R$, where $R$ is the radius of the colloid probe.

Figure I. Shear force as a function of normal load at a sliding velocity of 10 $\mu$m·s$^{-1}$ for each IL in this study. The shear force presented is the average of at least three normalised datasets taken with the same cantilever/colloidal probe combination. Squares: PAF, diamonds: PAN, triangles: EtAN, stars: EAN, circles: EAF, crosses: DMEAF. Forces are normalised by $2\pi R$, where $R$ is the radius of the colloid probe.
Figure J. Shear force as a function of normal load at a sliding velocity of 5 μm·s⁻¹ for each IL in this study. The shear force presented is the average of at least three normalised datasets taken with the same cantilever/colloidal probe combination. Squares: PAF, diamonds: PAN, triangles: EtAN, stars: EAN, circles: EAF, crosses: DMEAF. Forces are normalised by 2πR, where R is the radius of the colloid probe.

Figure K. Shear force as a function of normal load at various sliding velocities for a silica colloid probe sliding against a mica surface in PAN. Diamonds: 40 μm·s⁻¹, squares: 30 μm·s⁻¹, triangles: 20 μm·s⁻¹, crosses: 10.0 μm·s⁻¹, stars: 5 μm·s⁻¹. The dashed vertical line delineates the multilayer regime from the boundary regime.