Supporting information

Effects of the ionic structures on shear thickening fluids composed of ionic liquids and silica nanoparticles

Jianbin Qin, Guangcheng Zhang*, Zhonglei Ma, Jiantong Li, Lisheng Zhou, Xuetao Shi*

Department of Applied Chemistry, School of Science, Northwestern Polytechnical University, Xi'an 710072, P. R. China.

Corresponding author: Guangcheng Zhang Email: zhangguc@nwpu.edu.cn

Corresponding author: Xuetao Shi Email: shixuetao@nwpu.edu.cn

Telephone: +86-29-88431680. Fax: +86-29-88431680.

The osmotic mixing of the polymer solvation layers on surface of approaching particles with the dispersing medium as well as the elastic compression of them can be described by two repulsive potential functions.[1] For our case, the mixing term is ignored for the polymers solvation layers are same as the dispersing medium. The repulsive potential function of the elastic compression as follows,

$$V_{elastic} = (\frac{2\pi a k_B T \delta^2 \varphi \rho}{M}) \left[\frac{h}{\delta} ln \left[\frac{h}{\delta} (\frac{3 - \frac{h}{\delta}}{2})^2 \right] - 6\ln \left(\frac{3 - \frac{h}{\delta}}{2} \right) + 3(1 - \frac{h}{\delta}) \right] \quad \text{(S1)}$$

where, a is the particle radius; k_B is the Boltzmann constant; T is the temperature of the system; δ is the solvation layer thickness; h is the distance between two particles; φ is the volume fraction of the dispersing medium contained in the solvation layers (equal to 1 for our case); ρ is the medium density; M is the molecular weight of a oligomer chain of the dispersing medium.

When $0 < h < 2\delta$, the steric hindrance force expression is got by differentiating the potential functions with respect to the distance between particles for a constant temperature system.

$$F_{elastic} = -\frac{dV_{elastic}}{dh} = (\frac{2\pi a k_B T \delta^2 \rho}{M})[2\ln(2) - ln(h/\delta\,(3 - h/\delta)\text{^}2)$$

(S2)

$$F_{steric} = F_{elastic} \sim \delta^2 \left[2\ln{(2)} - ln(\frac{h}{\delta}\left(3 - \frac{h}{\delta}\right)^2) \right] \tag{S3}$$

Table S1 Conductivity of the dispersing medium

Sample	PEG-400	$[EMIm]BF_4$	$[BMIm]BF_4$	$[EOHMIm]BF_4$
Conductivity	3.91×10^{-4} S/m	1.83 S/m	0.35 S/m	0.68 S/m

Table S2 Dynamic knife stabbing testing sample parameters

Label	Dimension: Length (cm) by width (cm)	STF weight percentage (%)	Single layer areal density (g/m^2)	Number of layers in target
Kevlar	15×15	0.00	240.00	10
(PEG-400/SiO_2)-Kevlar	15×15	48.08	462.25	8
($[EMIm]BF_4/SiO_2$)-Kevlar	15×15	42.17	415.01	8
($[BMIm]BF_4/SiO_2$)-Kevlar	15×15	45.83	443.05	8
($[EOHMIm]BF_4/SiO_2$)-Kevlar	15×15	40.29	401.94	8

Table S3 Tensile strength testing sample parameters

Label	Number of layers in sample	Layer areal density (g/m^2)	STF weight percentage (%)	Dimension: Length (cm) by width (cm)
Kevlar	1	240.00	0.00	15×4
(PEG-400/SiO_2)-Kevlar	1	462.25	48.08	15×4
([EMIm]BF_4/SiO_2)-Kevlar	1	415.01	42.17	15×4
([BMIm]BF_4/SiO_2)-Kevlar	1	443.05	45.83	15×4
([EOHMIm]BF_4/SiO_2)-Kevlar	1	401.94	40.29	15×4

Table S4 Conductivity of neat Kevlar fabrics and STF-treated Kevlar fabric composites

Sample	Neat Kevlar fabrics	(PEG-400/SiO_2)/Kevlar fabrics	([EMIm]BF4/SiO_2)/Kevlar fabrics	([BMIm]BF4/SiO_2)/Kevlar fabrics	([EOHMIm]BF4/SiO_2)/Kevlar fabrics

Conductivity	0.568×10^{-10} S/m	0.312×10^{-10} S/m	0.327×10^{-4} S/m	0.178×10^{-4} S/m	0.216×10^{-4} S/m

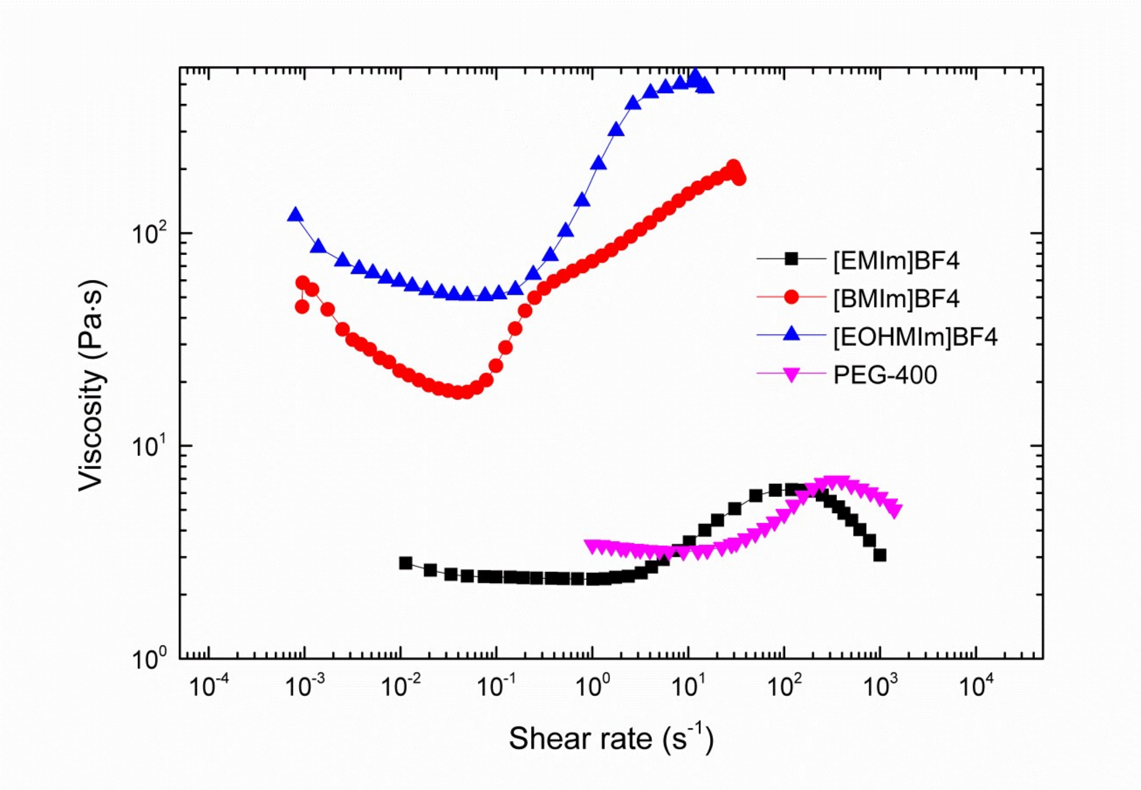

Figure S1 Shear rate dependencies of viscosity for the dispersions with 15 vol % silica nanoparticles in PEG-400, [EMIm]BF_4, [BMIm]BF_4 and [EOHMIm]BF_4, respectively

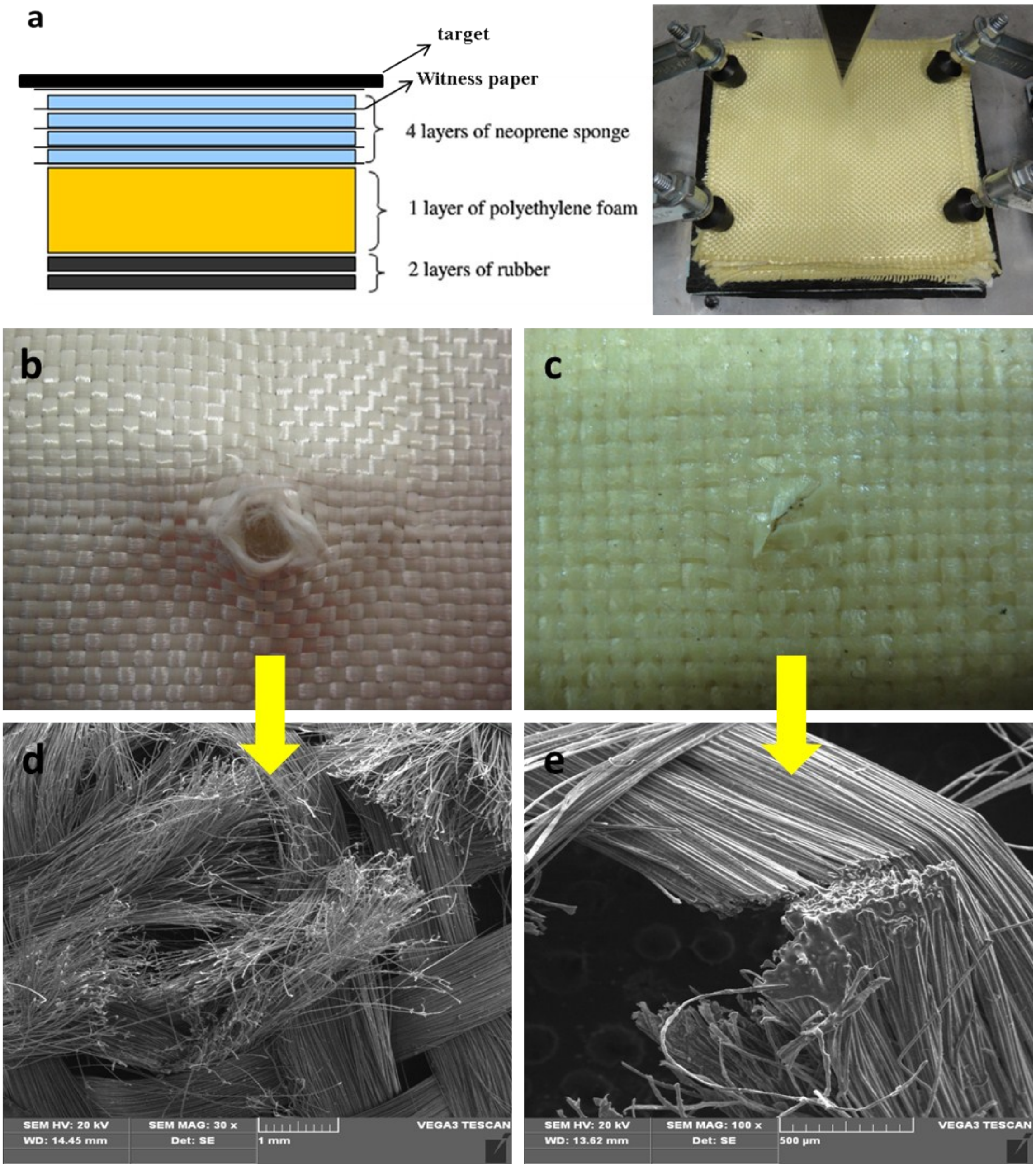

Figure S2 (a) schematic illustrations of the testing sample installation and the photograph of it. The dynamic knife stabbing tests results for the same impact energy: **(b)** the photograph of the breaking sample for neat Kevlar fabric; **(c)** the photograph of the breaking sample for STF-treated Kevlar fabric; **(d)** SEM image of the breaking sample for neat Kevlar fabric in (b); **(e)** SEM image of the breaking sample for STF-treated Kevlar fabric in (c)

REFERENCES

(1) Vincent, B.; Edwards, J.; Emmett, S.; Jones, A. Depletion Flocculation in Dispersions of Sterically-Stabilised Particles ("soft Spheres"). *Colloids Surf.* **1986**, 18, 261–281.