

All the P(VI/C₂TFSI) seems to succeed in samples examined agree with superposition in the $a_T\omega$ range from the glass to the terminal region as is the case for this has been observed in other imidazolium based PILs.^{9,10} The master curve data for the P(VI/C₂TFSI) samples with $x_q = 0.05$ and 0.09 ~~is absent~~ could not be measured in the $a_T\omega$ region corresponding to the terminal region because degradation of the samples occurs at temperatures over ~~240 °C~~ 240 °C. The clear rubbery region around $a_T\omega = 10^{-5}$ s⁻¹ for PVI and P(VI/C₂TFSI) with $x_q \leq 0.70$ indicates that polymers with $M_v = 1.4 \times 10^5$ are entangled with each other to show one another and therefore exhibit elasticity.

The magnitude of the rubbery modulus for PVI corresponds to that ~~for of~~ P(VI/C₂TFSI) with $x_q = 0.09$ but is lower than that for P(VI/C₂TFSI) with $x_q = 0.05$ (Figure 3a). The P(VI/C₂TFSI) with $x_q \leq 0.10$ are took as is taken to be the ionomer species. It has been reported that ionomers form ion aggregates ~~consisting of their ionic groups due to the electrostatic attraction caused between them.~~^{16,17} The ion aggregates in ionomers act as physical cross-linkers ~~to and so~~ contribute ~~the to their~~ elastic component, ~~consequently they~~ behavior; these aggregates enhance the magnitude of the plateau modulus and ~~elongate~~ increase the terminal relaxation time.¹⁸ In this sense, ~~enhance of the~~ increased rubbery modulus for P(VI/C₂TFSI) ~~with when~~ $x_q = 0.05$ ~~is perhaps~~ may be due to the presence of ionic aggregates. It is important to note that ionomers with large counter ions form few or no ion aggregates and show ~~marked~~ plasticizing effect behavior to decrease the terminal relaxation time.¹⁵ Although P(VI/C₂TFSI) ~~possess~~ possesses a large counter anion, ~~a few~~ the low amount of TFSI⁻ ions in the P(VI/C₂TFSI) with low x_q would not act as a plasticizer ~~and form a bit.~~ A small quantity of ion aggregates forms to enhance the rubbery modulus. The contribution of the ionic aggregates ~~was canceled~~ becomes negligible due to the increase of plasticizing effect for the P(VI/C₂TFSI) ~~with when~~ $x_q = 0.09$. With x_q up to 0.46, the plasticizing effect ~~markedly decrease~~ significantly decreased the terminal response time (Figure 3b).

The ~~master~~ master curves of P(VI/C₂TFSI) samples with higher $x_q (\geq 0.70)$ ~~shows~~ show additional shoulders in the glass-to-rubber transition region ($a_T\omega = 10^{-3}$ s⁻¹) ~~(; Figure 3c)~~. The additional shoulders are ~~enhanced~~ more pronounced with increasing x_q . ~~Besides, In Figure 4, it can be seen that~~ tan δ curves for the P(VI/C₂TFSI) samples with $x_q \geq 0.82$ ~~shows~~ show two peaks ~~(Figure 4)~~. These characteristic viscoelastic features ~~has~~ have also been observed in PC₂TFSI and PC₄TFSI ~~and has~~ but were not ~~been~~ observed in PC₄X ~~with~~ containing the smaller

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Golden English Editing
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註解 [Editor2]:
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註解 [Editor3]:
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counter ions of BF_4^- and PF_6^- .^{9,10} We have concluded that the origin of the additional shoulders is due to the rotational motion of large ellipsoidal TFSI⁻ ions in the polymer matrix polymers in the previous paper.¹⁰ This proposal conclusion is supported by the present finding that the additional shoulders are enhanced become more pronounced with increasing x_q of P(VI/C₂TFSI).

Here we propose another candidate possibility for the origin of the additional shoulders observed in the PILs with TFSI⁻ counter anions. Polyisobutylene¹⁹⁻²² or the concentrated polystyrene solution²³ were known to solutions²³ show the additional shoulders in the glass-to-rubber transition region. The origin of the additional shoulders in these systems was interpreted as the sub-rouse mode, which is the local torsional motion between two segmental beads.^{21,22} The sub-rouse mode is observed in the polymer system in which where intra-macromolecular cooperativity is dominant in comparison with the over inter-macromolecular cooperativity. In the TFSI-contained PIL system, the dissociated TFSI⁻ ions behave act as a good solvent and would inhibit the cooperative motion between polymer chains, which; this results in the broad rouse relaxation time distribution.

If the additional shoulders actually derive from occur due to the presence of large TFSI⁻ ions as discussed above, electrically neutral polymers containing TFSI⁻ salts also should show the similar viscoelastic behavior. Lodge and his coworkers investigated the rheological aspects of the polymethylmethacrylate (PMMA) in C₂TFSI solution solutions.²⁴ Their measurement frequency range is was limited into the rubbery and through terminal region regions, and consequently so they did not mention presence of the observe additional shoulders in their system study. However, the tan δ curve for their system with the a PMMA weight concentration of 60% seems appeared to have two peaks. Hence, the polymer solution diluted by TFSI possibly could potentially show the additional shoulders even if PILs are unused not used.

3.3 Shift Factor

Figure 5a represents shows the relationship between $\log a_T$ and temperature for the P(VI/C₂TFSI) samples with various varying x_q . Solid lines indicate that the best fit curves to the data using the Williams-Landel-Ferry (WLF) equation:

$$\log a_T = \frac{-c_1(T - T_r)}{c_2 + T - T_r} \quad (23)$$

where c_1 and c_2 are constants and T_r ~~means~~ is the reference temperature. T_r ~~equals~~ is equal to T_0 in ~~our~~ this study. Fitting parameters of c_1 and c_2 ~~tabulated~~ can be found in Table 1 and increase with increasing x_q .

~~—————~~ ~~In order~~ We plotted the log a_T data with respect to ~~consider~~ TT_0^{-1} to examine the effect of charge density upon ~~the macro dynamics~~ properties without the contribution of glass transition behavior, ~~the log a_T data are plotted against TT_0^{-1} and shown in~~ (see Figure 5b. All). Obviously, it is not possible to describe all of the data ~~are obviously unable to be described by a universal WLF function~~ parameters. Solid lines in Fig. 5b are best fit curves for each P(VI/C₂TFSI) using ~~eq 2~~ Eq 3 replaced by $T = TT_0^{-1}$ and $T_0 = 1$. Using the WLF fitting ~~curves~~ parameters, the fragility index m ~~as follows~~ is calculated using:

註解 [Editor5]:

CHECK: Should there be a T_r here? Please check.