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A High-Adhesion Polymer Gel for Polytetrafluoroethylene

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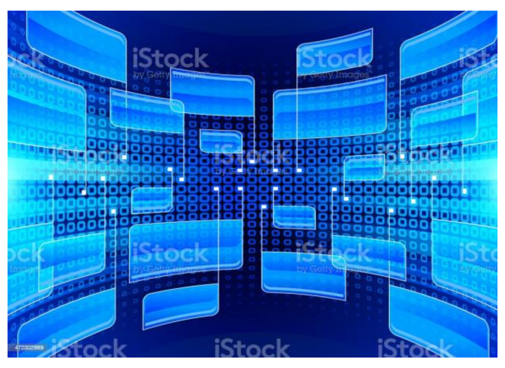
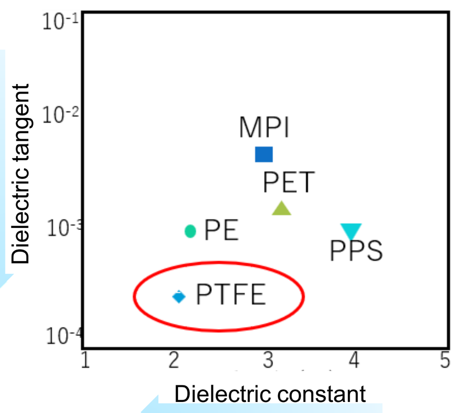
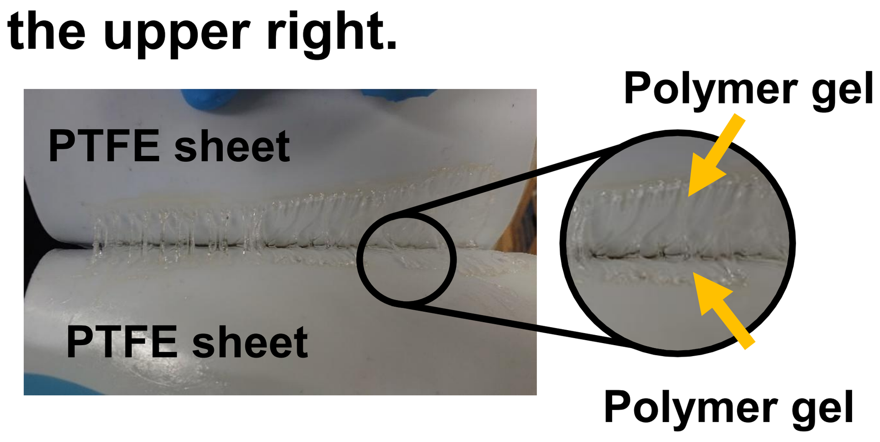
INTRODUCTION & AIM





Characteristics of PTFE
Low surface free energy
Low maximum coefficient of friction
Low dielectric constant and dielectric loss tangent

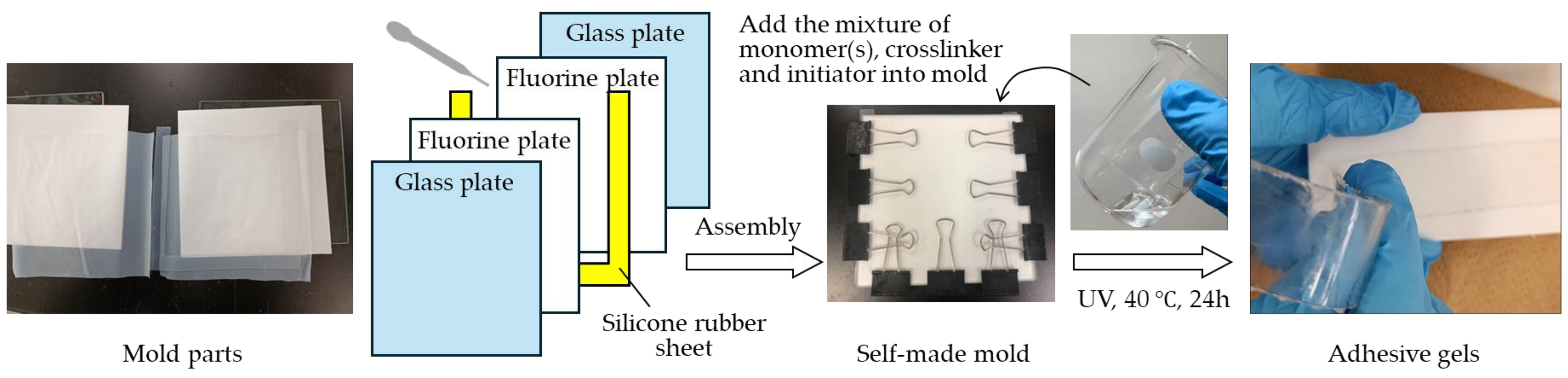
PTFE has a low dielectric constant and dielectric loss tangent, so it has been attracting lots of attention in the field of high speed communications.
However, PTFE is difficult to use due to its characteristics shown in the upper right.

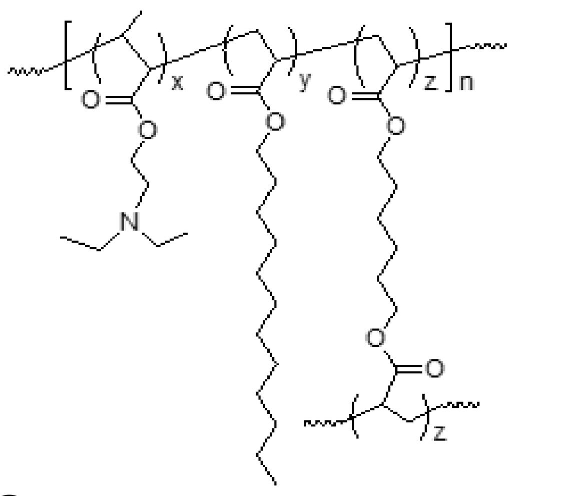


Other polymer gels peeled away from the interface, but this polymer peeled away from the middle.

In this work, we aim to investigate the relationship of the Adhesive strength and surface compatibility between PTFE and the synthesized polymer gel, and to clarify the factors contributing to the high adhesive strength to PTFE through viscoelasticity measurements.

METHOD

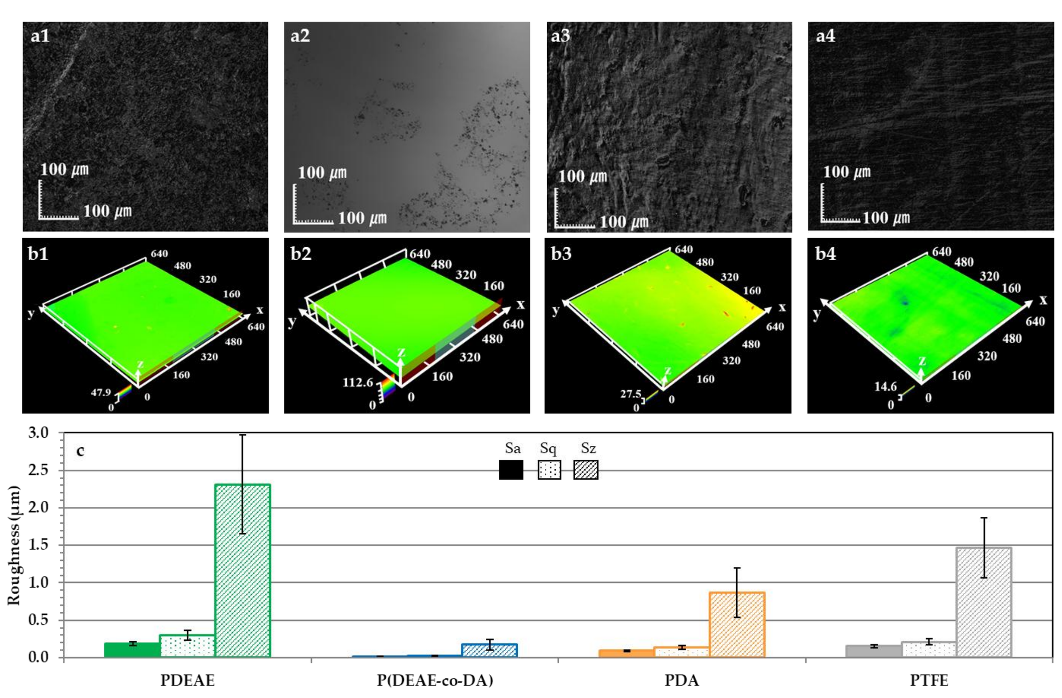




x=1, y=0: PDEAE
x=1, y=0.33: P(DEAE-co-DA)
x=0, y=1: PDA

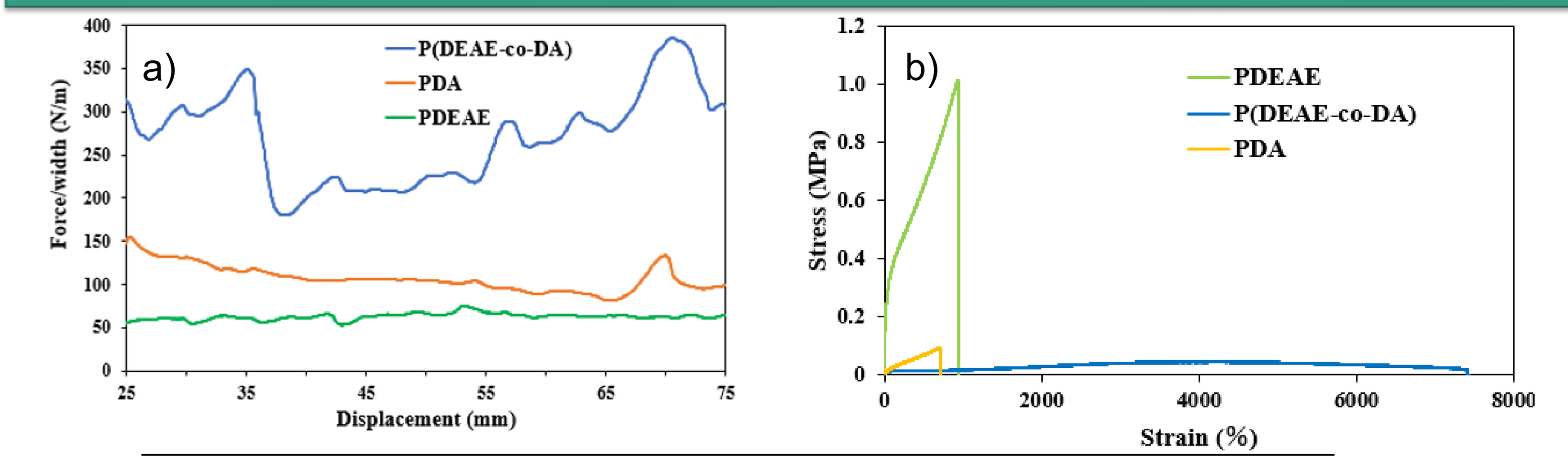
The molar amounts of DEAE, DA, HMPP and HDDA were fixed at 3.0 mol, 1.0 mol, 0.002 mol and 0.004 mol respectively.

- ●3D laser measurement
  →Observation of Polymer Gels Surface and PTFE Surface.
- ●Peel test (25 ℃)
  →Sample 300 mm (5-minute wait time), Peel speed 300 mm/min
- ●Mechanical Properties of Adhesive Gels
  →The relationship between mechanical properties and adhesive strength
- ●Contact angle measurement
  → Evaluation of the interface between Gel and PTFE
- ●Dynamic Mechanical Analysis (DMA)
  →G', G", tanδ, Relaxation time (τ) and activation energy (Ea)



Surface characterization of three types of gels and PTFE. (a) Scanning mode digital microscopy images and (b) 3D profilometry reconstructions for (a1,b1) PDEAE, (a2,b2) P(DEAE-co-DA), (a3,b3) PDA, and (a4,b4) PTFE. (c) Summary of 3D height parameters (Sa, Sq, Sz).

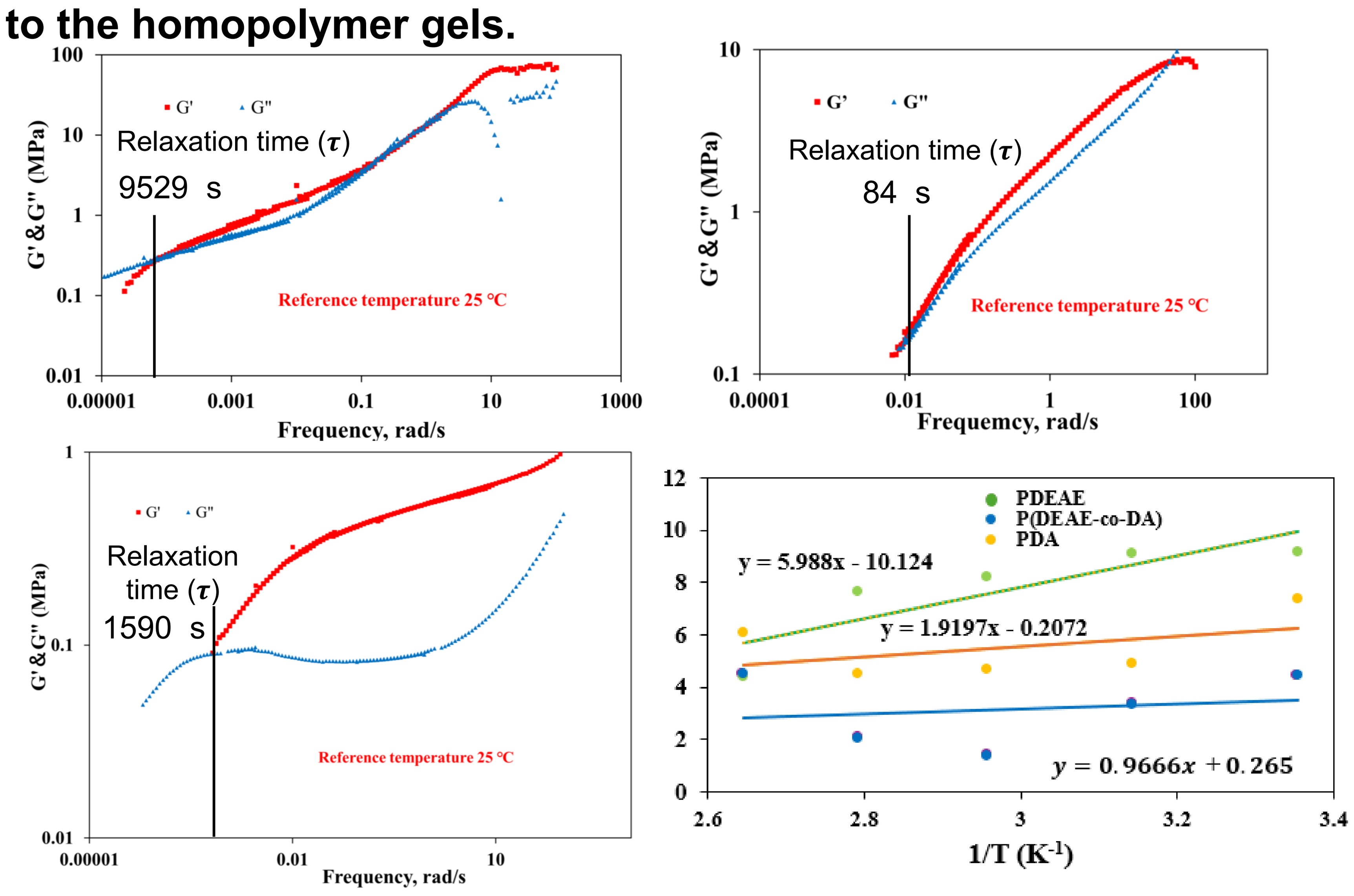
RESULTS & DISCUSSION



Gels	Adhesive strength Ave (N/m)	Adhesive strength Max (N/m)	Peel energy (J/m²)
PDEAE	62.8	77.2	117.5
P(DEAE-co-DA)	339.7	536.0	713.4
PDA	75.7	154.8	172.4

Gels	Ultimate Tensile Strength (MPa)	Breaking Strain (%)	Toughness (MJ/m³)	Young's Modulus (MPa)
PDEAE	0.993	936.0	5.228	2.171
P(DEAE-co-DA)	0.045	7309.0	2.185	1.609
PDA	0.096	699.0	0.384	2.371

The adhesive strength and peel energy of P(DEAE-co-DA) increased from 4 to 6 times compared to that of the homopolymer gels. P(DEAE-co-DA) exhibited the lowest tensile strength and the highest fracture strain. The Young's modulus decreased compared to the homopolymer gels.



Relaxation time(τ) and activation energy (Ea)

Master curves were created from frequency-dependent measurements at each temperature based on the temperature-time conversion law. The activation energy (Ea) was calculated by multiplying the slope of the approximate line of the plot by the gas constant R (8.314 $JK^{-1}mol^{-1}$). P(DEAE-co-DA) displayed higher tanδ, shorter τ, and a significantly lower Ea (8.03 $kJmol^{-1}$) compared to PDEAE (49.7 $kJmol^{-1}$) and PDA (15.9 $kJmol^{-1}$). This low Ea enhances chain mobility, enabling side chains to align with the PTFE surface, strengthening van der Waals interactions. The superior adhesive strength of P(DEAE-co-DA) primarily stems from enhanced viscoelastic energy dissipation.

CONCLUSION

P(DEAE-co-DA) showed the highest P, which was about 4 to 6 times higher than that of homopolymer gels of PDA and PDEAE.
For P(DEAE-co-DA), its τ and Ea were lowest.
→The ease of molecular movement within the gel affects the adhesive strength between the gel and PTFE.

FUTURE WORK / REFERENCES

We would like to examine the effect of the monomer ratio on adhesive strength.