Improving dielectric permittivity by incorporating PDMS-PEG multi block copolymer into PDMS network

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Improving dielectric permittivity by incorporating PDMS-PEG multi block copolymer into PDMS network

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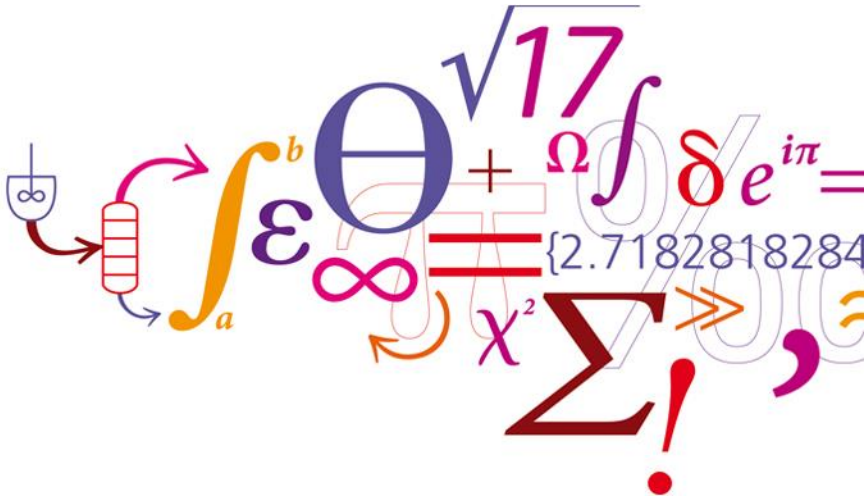
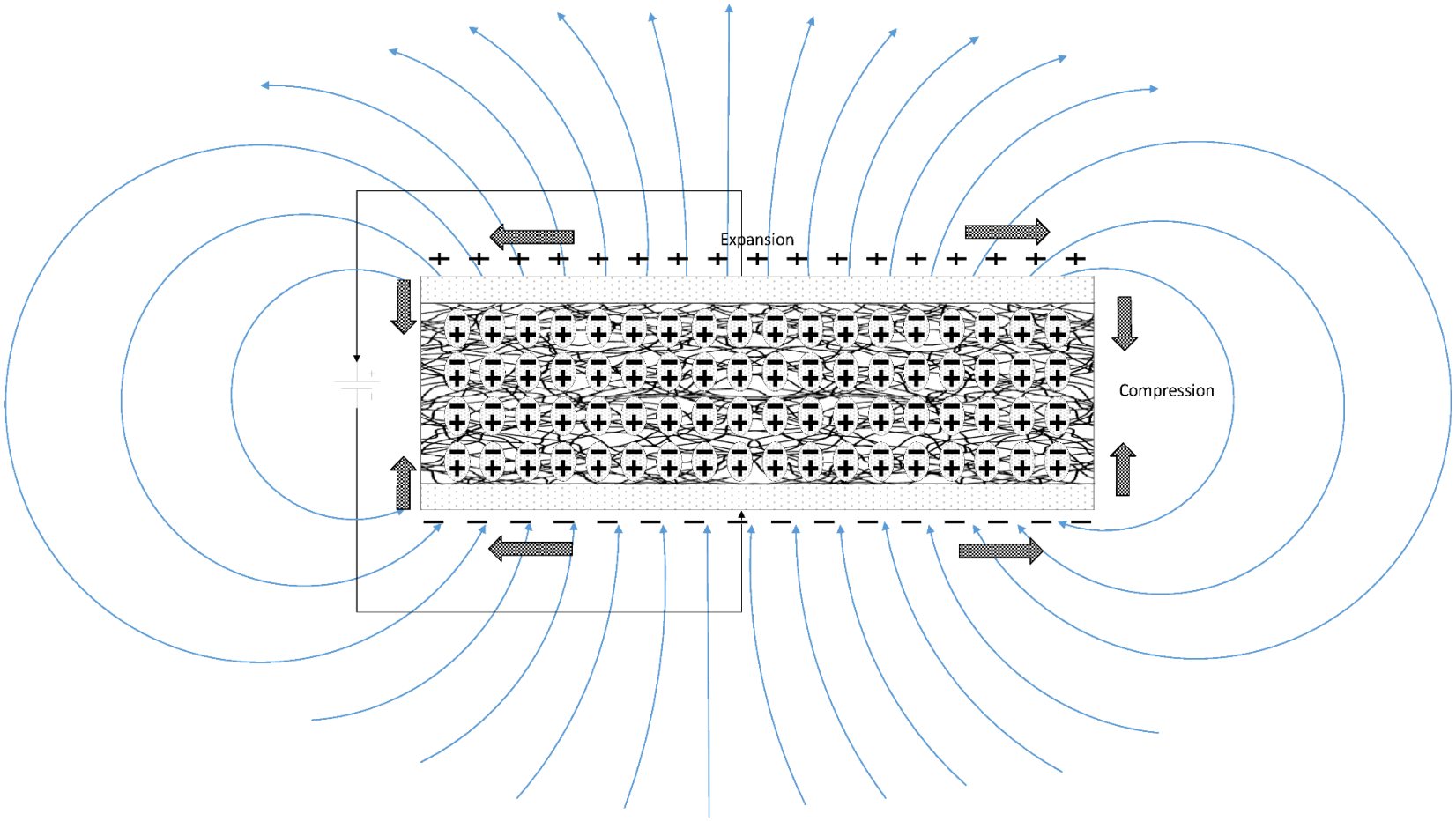


DTU Chemical Engineering
Department of Chemical and Biochemical Engineering

Outline

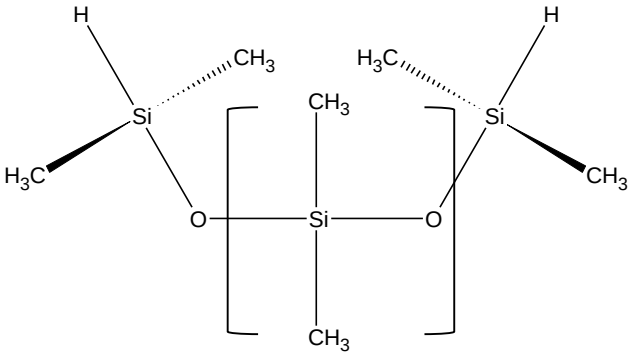
- INTRODUCTION:
  - Dielectric electroactive polymer (DEAP).
  - Poly(dimetylsiloxane) (PDMS) versus Poly(ethylene glycol) (PEG)
  - Morphology of block copolymer and phase continuity
  - Experimental setup and characterization methods
- RESULTS
  - Properties of PDMS-PEG multi block copolymer
  - Binary polymer blends of PDMS-PEG block copolymer and commercial PDMS elastomer
- CONCLUSION

Principal of DEAP material



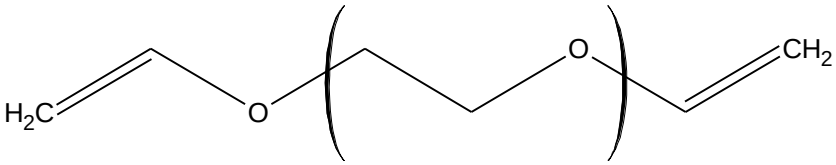
PDMS versus PEG

PDMS



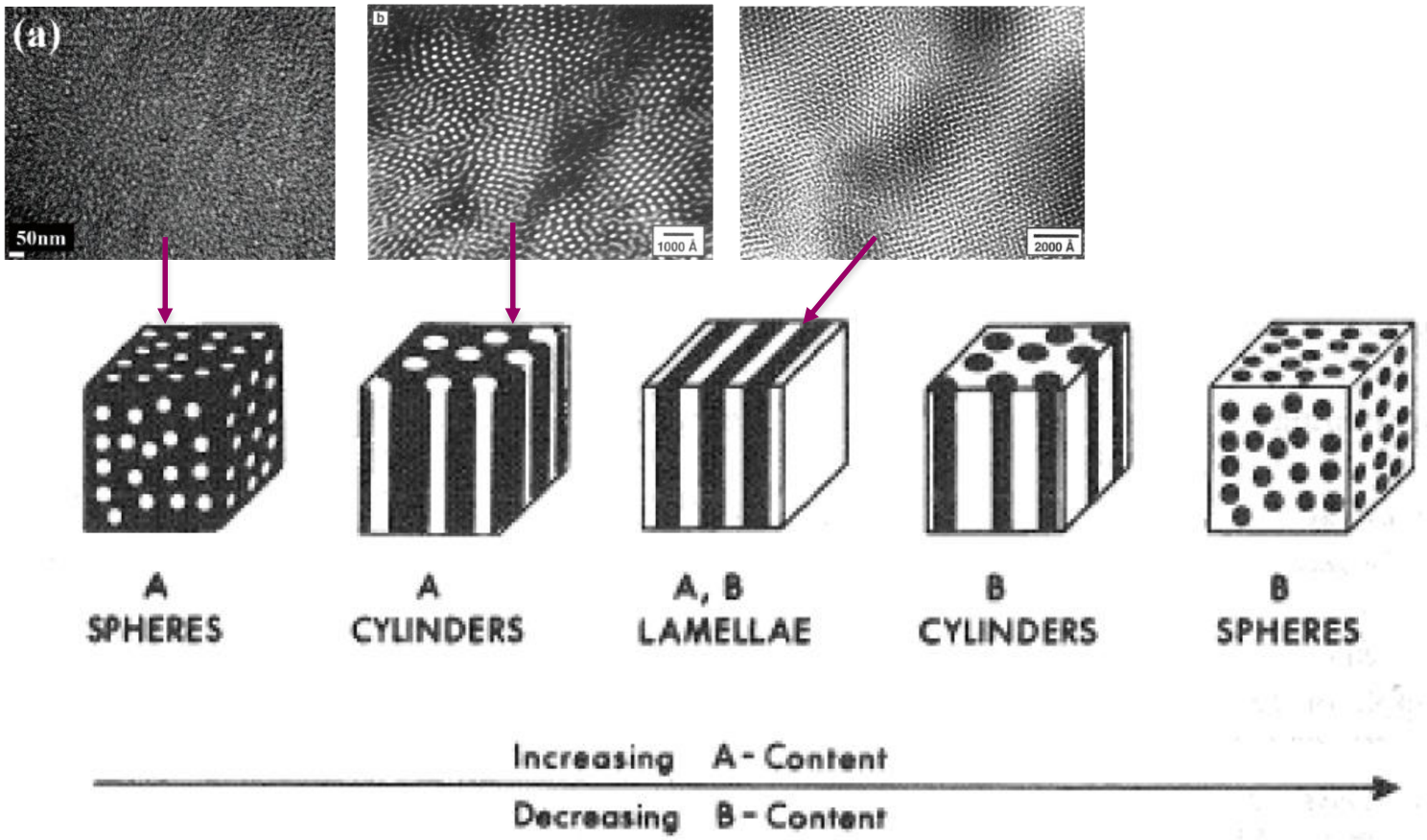
- Hydrophobic
- Low surface energy
- Low conductivity
- Wide temperature range
- High stability
- Low modulus
- Low permittivity

PEG



- Hydrophilic
- High surface energy
- Low toxicity
- High mobility in solution
- High permittivity
- High Conductivity

Morphology in block copolymer (AB) [1, 2]



[1] Bates, F. S., & Fredrickson, G. H. (1999). Block Copolymers—Designer Soft Materials. *Physics Today*, *52*(2), 32. doi:10.1063/1.882522

[2] *Khandpurj, A. K., et.al (1995). Diblock Copolymer Phase Diagram near the Order-Disorder Transition. Macromolecules, 28(26), 8796–8806.*

Phases in polymer blend

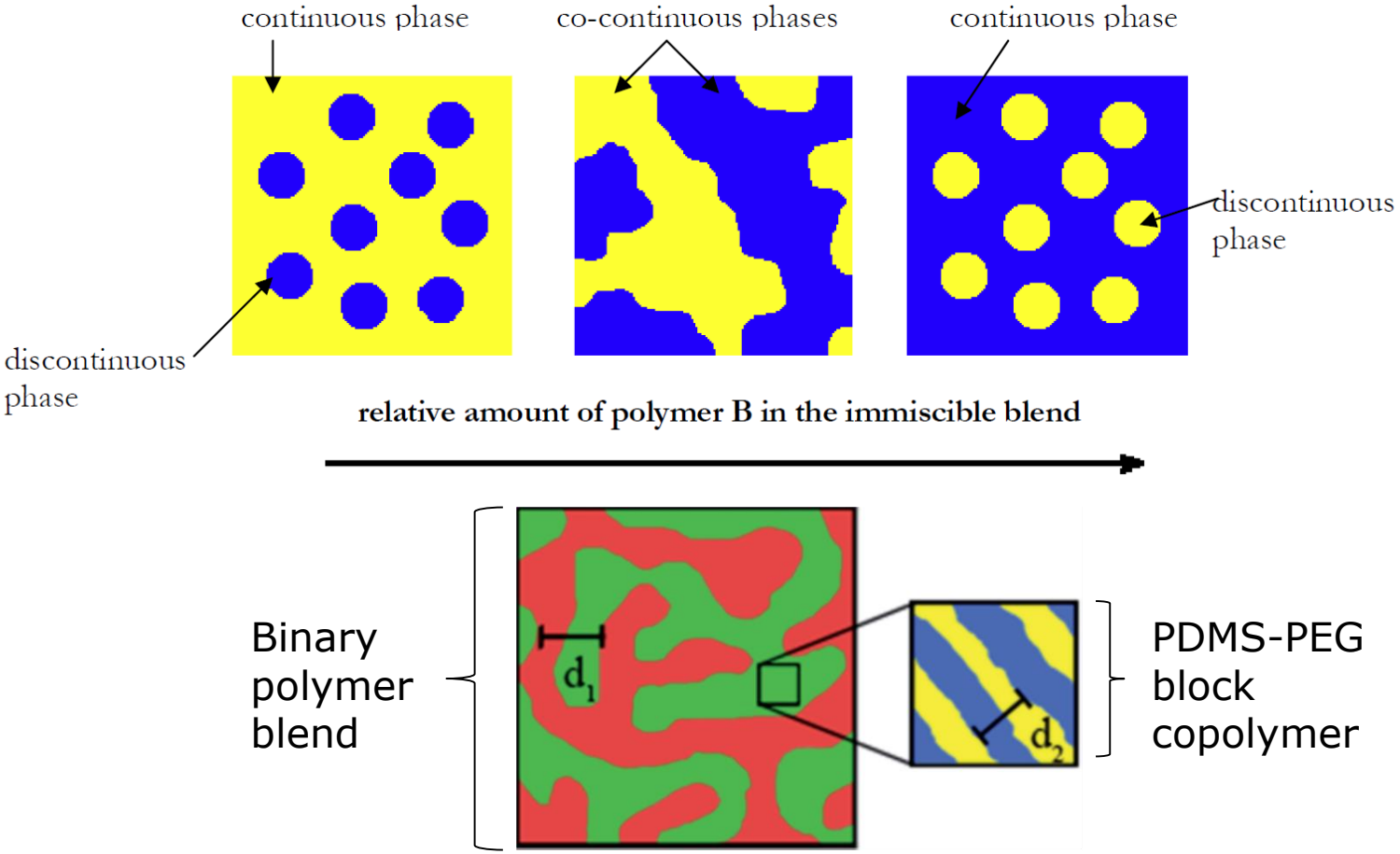


Illustration of PDMS: PDMS-PEG BC polymer blend

Habersberger, B. M.; Bates, F. S.; Lodge, T. P. Soft Matter 2012, 8, 3429–3441.

Sequence(s) of project

1st step - synthesize PDMS-PEG prepolymer

2nd step - Blending PDMS-PEG block copolymer with commercial PDMS elastomer

3rd step - crosslinking with methylhydrosiloxane-dimethylsiloxane copolymer (HMS-501)

Experimental setup

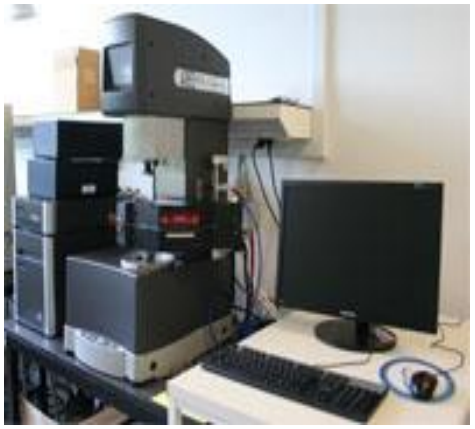
PDMS Hydride-terminated	Reactant	Average number of molecular weight M_n [g/mol]	No. of repeating units -reactant- (N)	No. of repeating units -block copolymer- (X)	Stoichiometry ratio *(r)*	*Volume fraction of PDMS* *(f_A)*
H21	PEG-DE	250,00	4	6	1,21	0,94
	PDMS Hydride-terminated	6000,00	81	5		
H11	PEG-DE	250,00	4	24	1,04	0,75
	PDMS Hydride-terminated	1050,00	14	23		
H03	PEG-DE	250,00	4	38	1,03	0,62
	PDMS Hydride-terminated	550,00	7	37		
SIH	PEG-DE	250,00	4	57	1,02	0,45
	PDMS Hydride-terminated	208,00	3	56		

Characterization

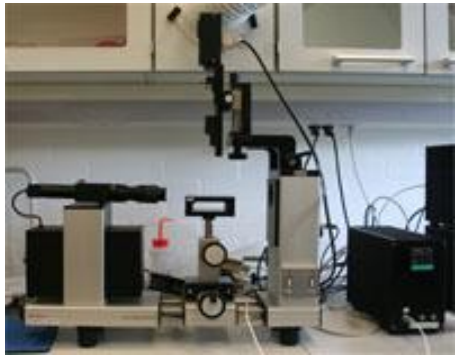
1. Chemical reaction
   - NMR (Si-H ~ 4.70ppm)
2. Mechanical properties
   - LVE properties.
   - Parallel plate (25 mm)
3. Electrical properties
   - Dielectric properties
   - 20 mm electrode
4. Contact angle
   - Sessile method
   - Static contact angle

1. Bruker 300 MHz NMR

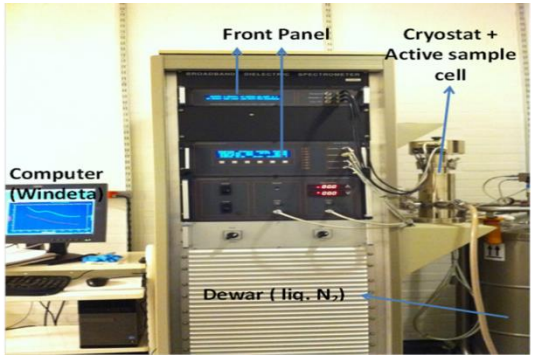
2. Rheometer (ARES-G2)



4. Dataphysics OCA20

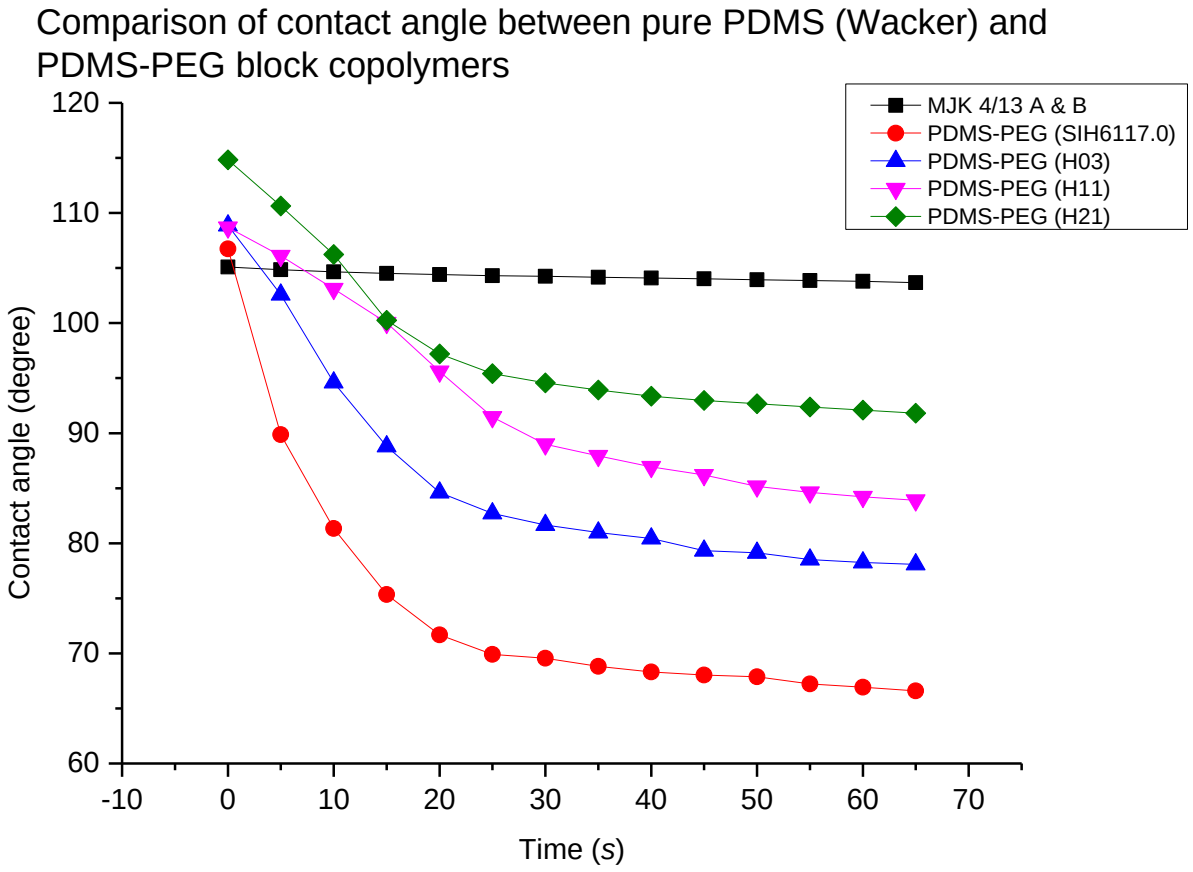


3. Novocontrol GmbH

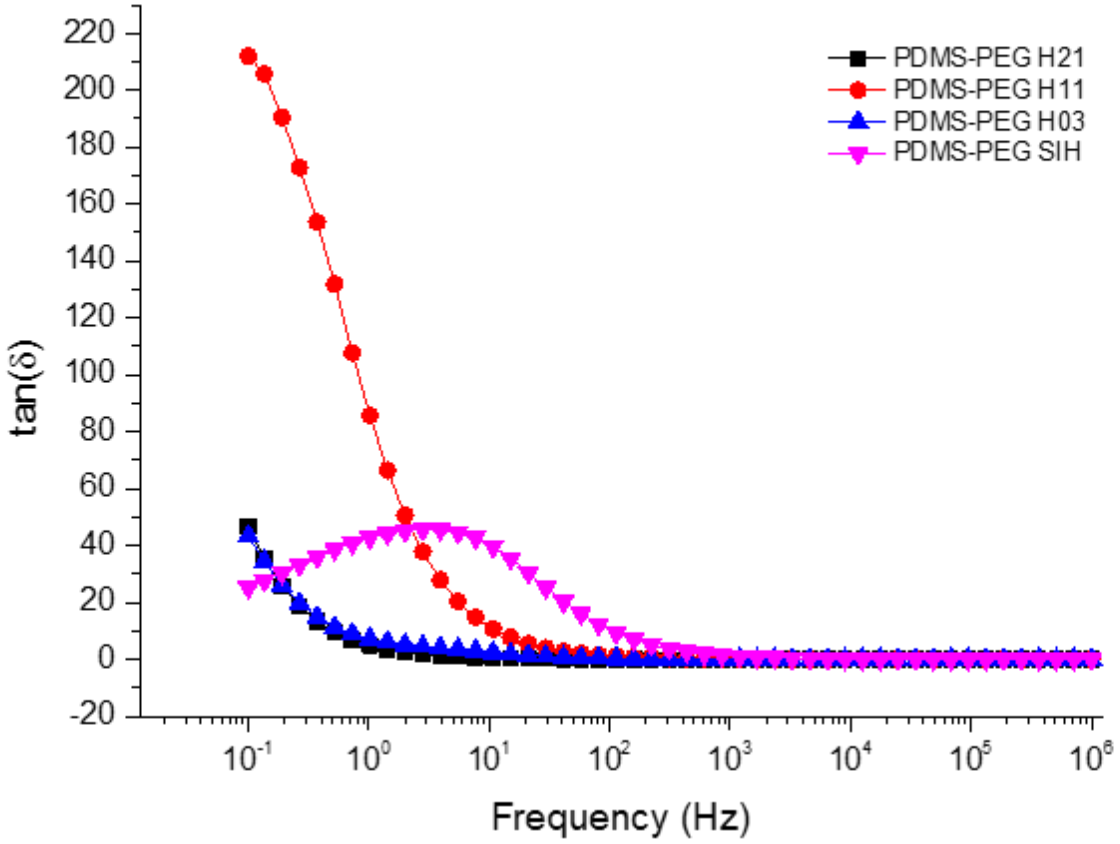


Result: Block copolymer (H21, H11, H03, SIH)

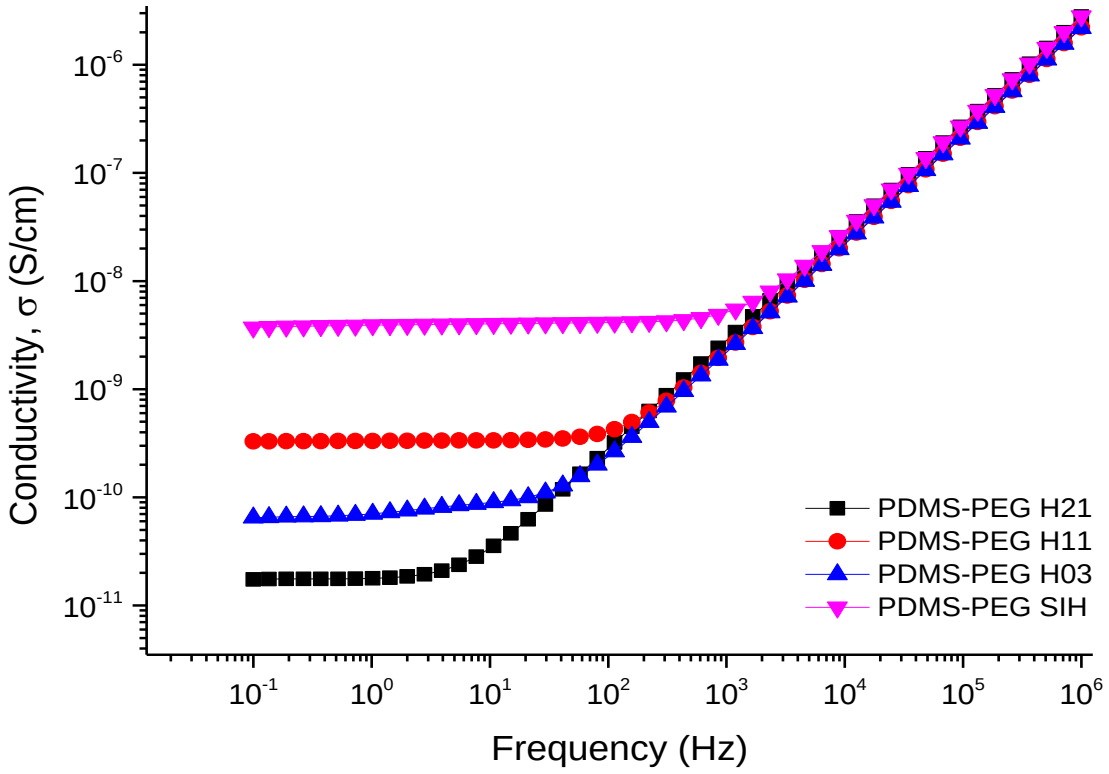
Contact angle for all block copolymer



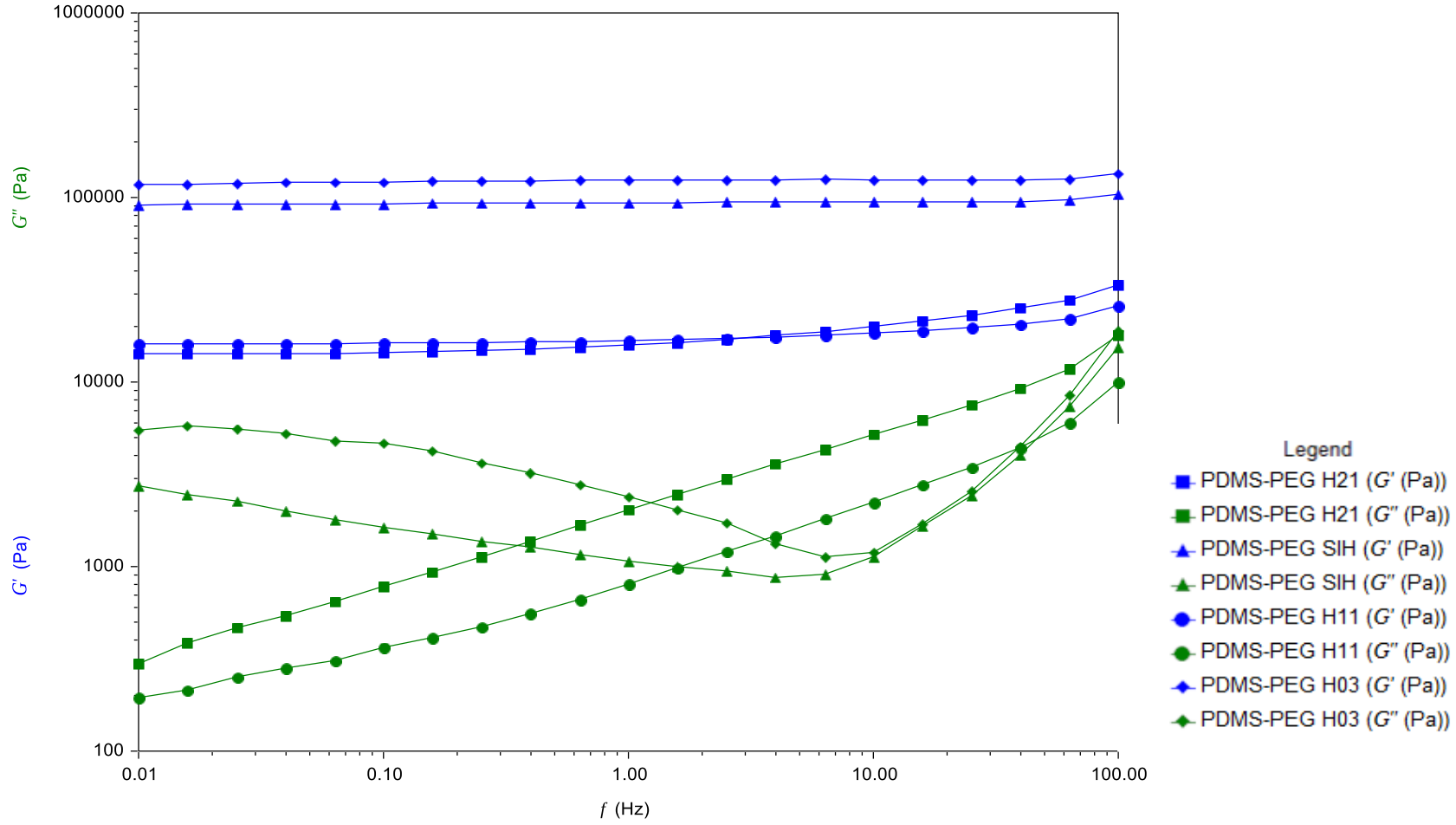
Comparison of Permittivity among H21, H11, H03 and SIH



Comparison of Conductivity among H21, H11, H03 and SIH

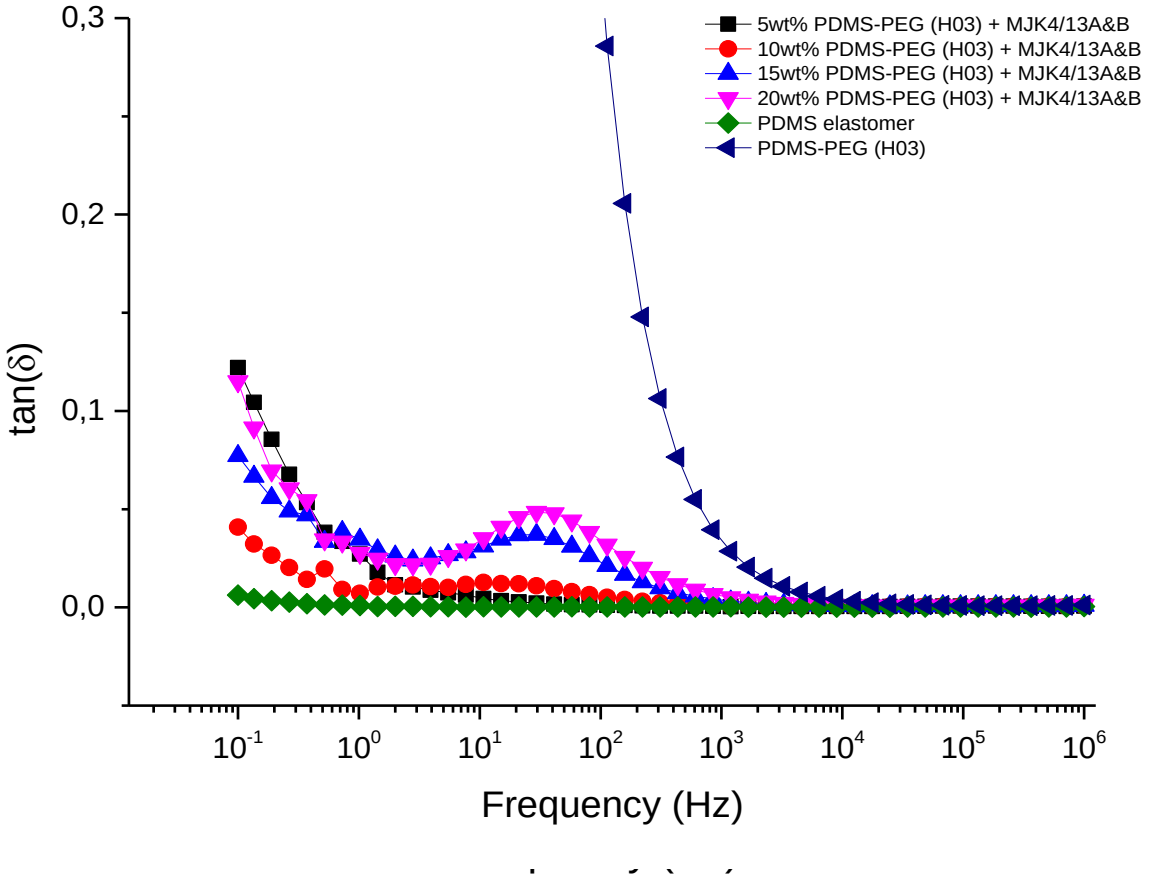


Comparison of modulus among H21, H11, H03 and SIH

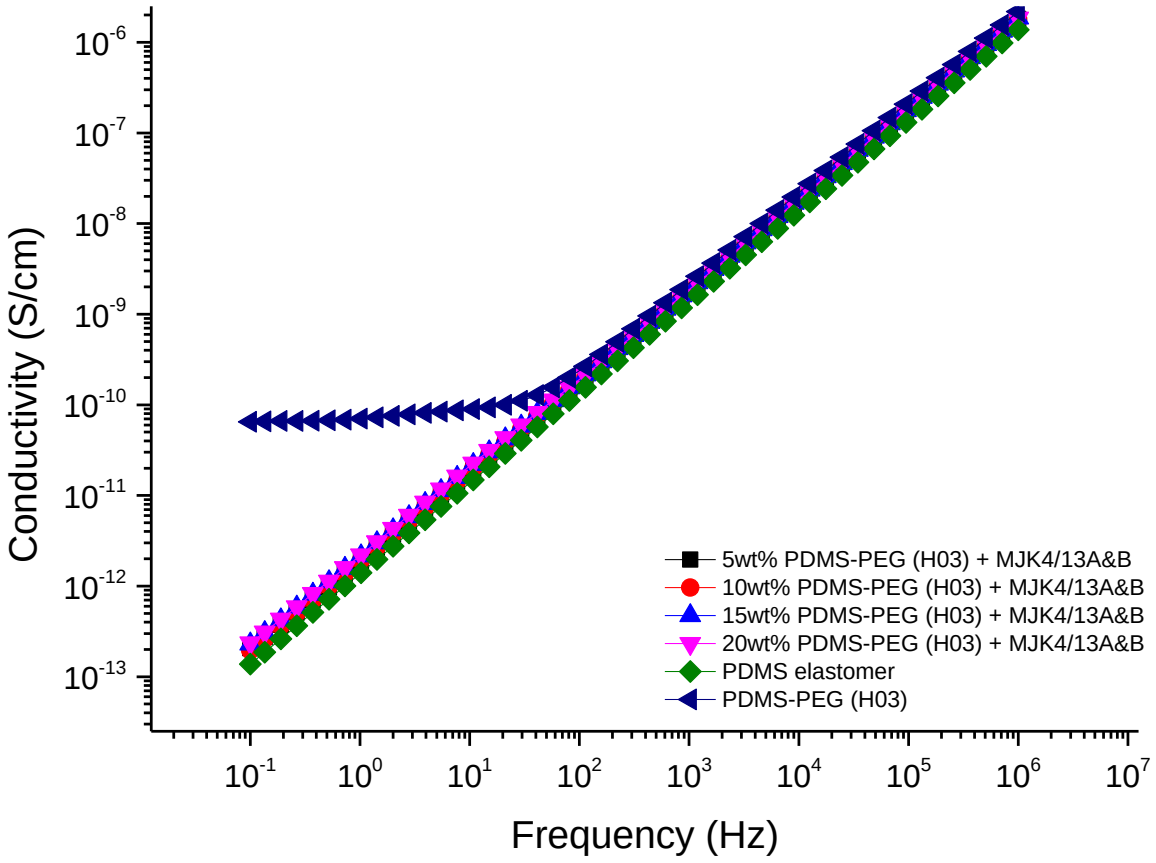


Result: Binary polymer blend of PDMS-PEG block copolymer and commercial PDMS elastomer

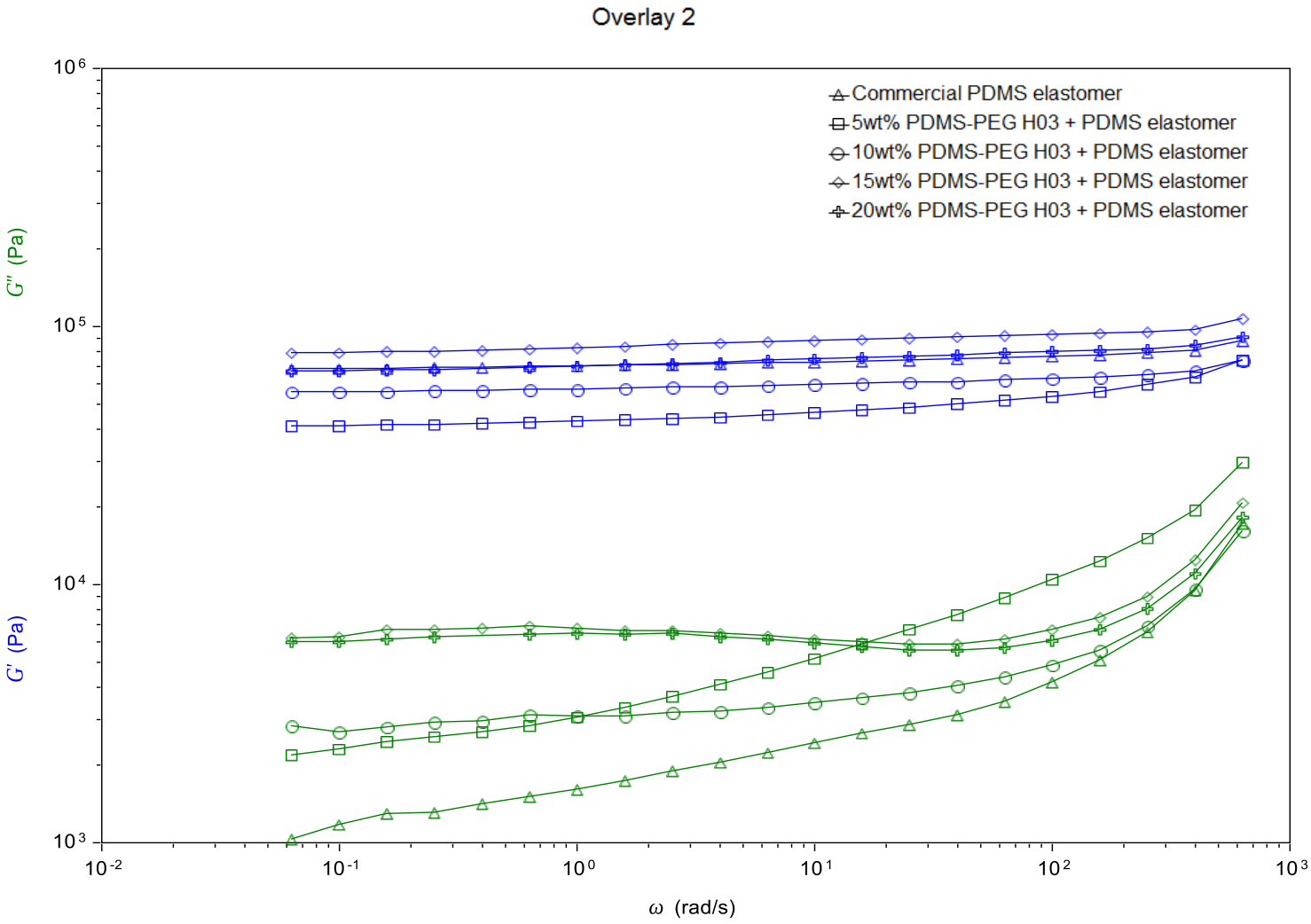
Comparison of permittivity for PDMS-PEG (H03) with commercial PDMS elastomer



Comparison of conductivity for PDMS-PEG (H03) with commercial PDMS elastomer



Comparison of modulus for PDMS-PEG (H03) with commercial PDMS elastomer



Conclusion

- PDMS-PEG is a conductive block copolymer (10^{-8} S/cm) with amphiphilic behaviour.
- Incorporating PDMS-PEG (H03) with commercial PDMS elastomer:
    - Improve storage permittivity up to 60% with low loss permittivity.
    - Maintain LVE properties compared to the commercial.
    - Has amphiphilic behaviour (contrast with PDMS elastomer).

Thank you

DPP Group