† Electronic Supplementary Information (ESI)

Enhancing relative permittivity by incorporating PDMS-PEG multi block copolymers in binary polymer blends

Aliff Hisyam A Razak,[a,b] Peter Szabo[a] and Anne Ladegaard Skov[a*]

[a] *Danish Polymer Center, Department of Chemical and Biochemical Engineering, Technical University of Denmark, Building 229, 2800 Kgs. Lyngby, Denmark. Email:al@kt.dtu.dk*
[b] *Department of Chemical Engineering Technology, Faculty of Engineering Technology, University of Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.*

Results

1. NMR spectra of multiblock copolymers

The NMR spectra for PDMS-PEG multiblock copolymers with different chain-length of PDMS are shown in figures (S1.a), (S1.b), (S1.c) and (S1.d).

a. PDMS81-PEG multiblock copolymer

^{1}H-NMR ($CDCl_3$, 300 MHz): δ 0.05 - δ 0.09 (m, 6 H's, -Si(C**H**$_3$)$_2$O-), δ 3.50 - δ 3.70 (m, 4 H's, -C$_2$**H**$_4$O-), δ 0.98 - δ 1.03 (t, 2 H's, -SiC**H**$_2$-), δ 3.53 - δ 3.57 (m, 2 H's, -CC**H**$_2$O-).

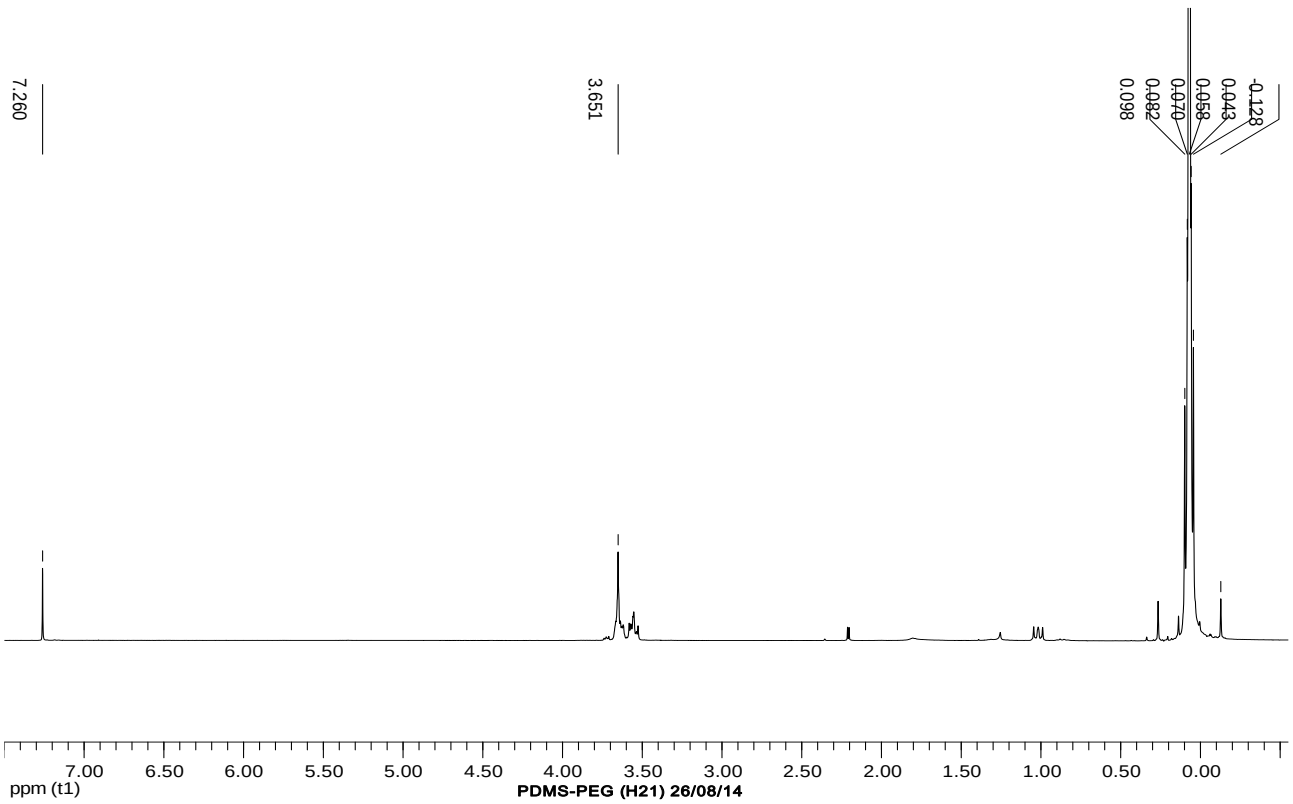

Fig. S1.a The NMR for PDMS81-PEG multiblock copolymer.

b. PDMS14-PEG multiblock copolymer

^{1}H-NMR ($CDCl_3$, 300 MHz): δ 0.05 - δ 0.09 (m, 6 H's, -Si(C**H**$_3$)$_2$O-), δ 3.50 - δ 3.70 (m, 4 H's, -C$_2$**H**$_4$O-), δ 0.98 - δ 1.03 (t, 2 H's, -SiC**H**$_2$-), δ 3.53 - δ 3.57 (m, 2 H's, -CC**H**$_2$O-)

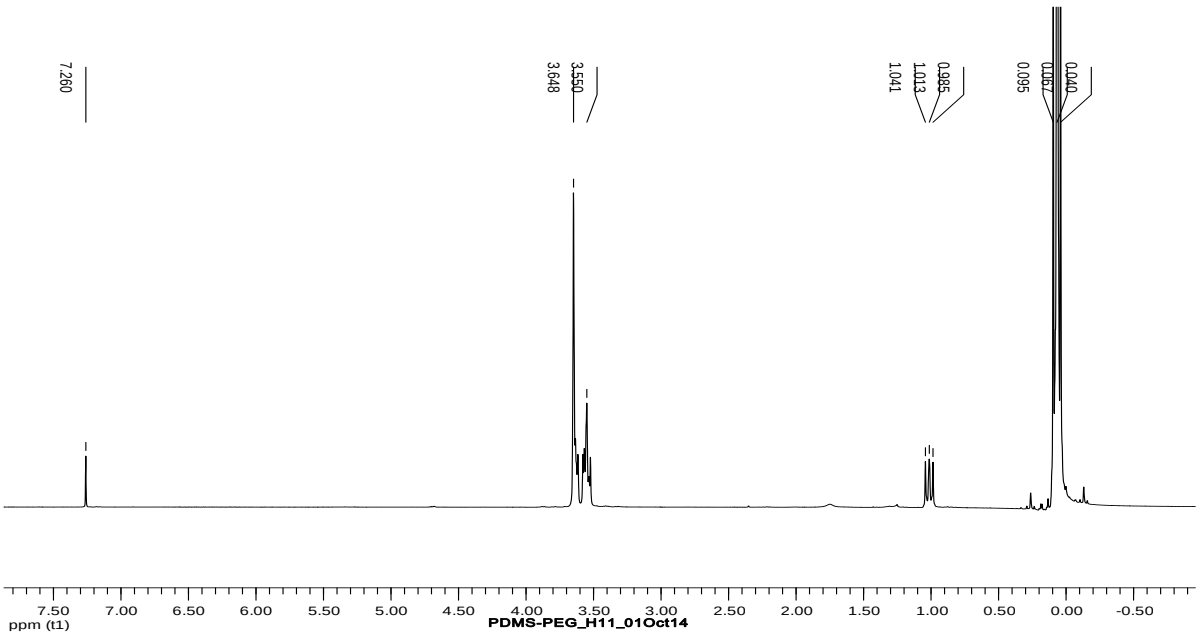

Fig. S1.b The NMR for PDMS14-PEG multiblock copolymer.

c. PDMS7-PEG multiblock copolymer

^{1}H-NMR ($CDCl_3$, 300 MHz): δ 0.05 - δ 0.09 (m, 6 H's, -Si(C**H**$_3$)$_2$O-), δ 3.50 - δ 3.70 (m, 4 H's, -C$_2$**H**$_4$O-), δ 0.98 - δ 1.03 (t, 2 H's, -SiC**H**$_2$-), δ 3.53 - δ 3.57 (m, 2 H's, -CC**H**$_2$O-).

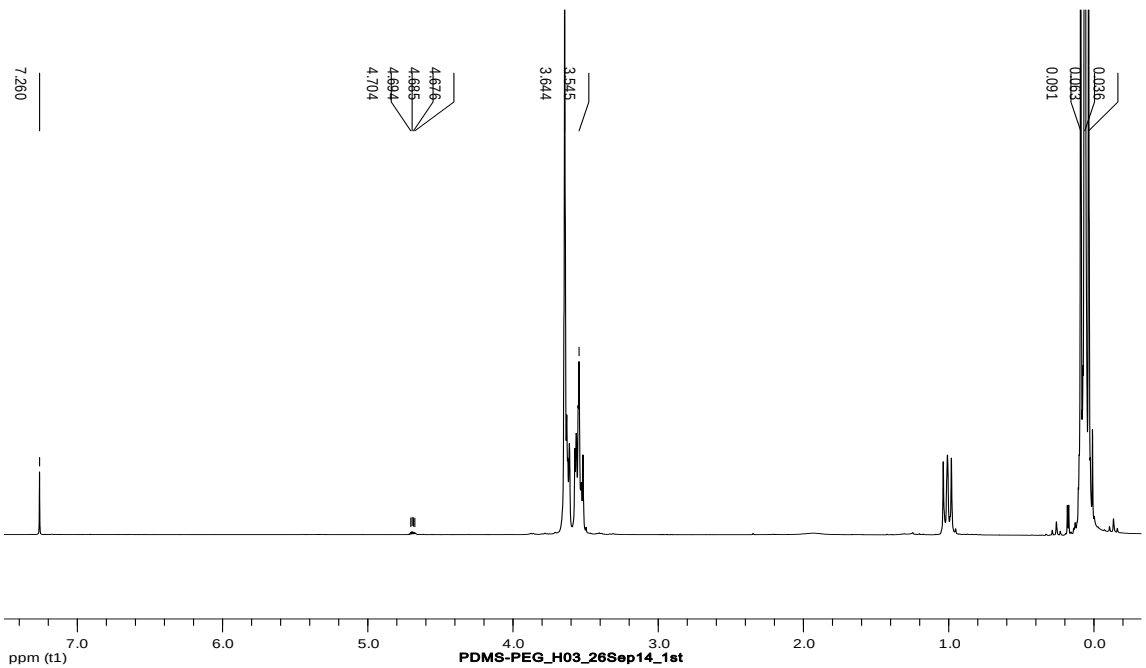

Fig. S1.c The NMR for PDMS7-PEG multiblock copolymer.

d. PDMS3-PEG multiblock copolymer

^{1}H-NMR ($CDCl_3$, 300 MHz): δ 0.05 - δ 0.09 (m, 6 H's, -Si(C**H**$_3$)$_2$O-), δ 3.50 - δ 3.70 (m, 4 H's, -C$_2$**H**$_4$O-), δ 0.98 - δ 1.03 (t, 2 H's, -SiC**H**$_2$-), δ 3.53 - δ 3.57 (m, 2 H's, -CC**H**$_2$O-)

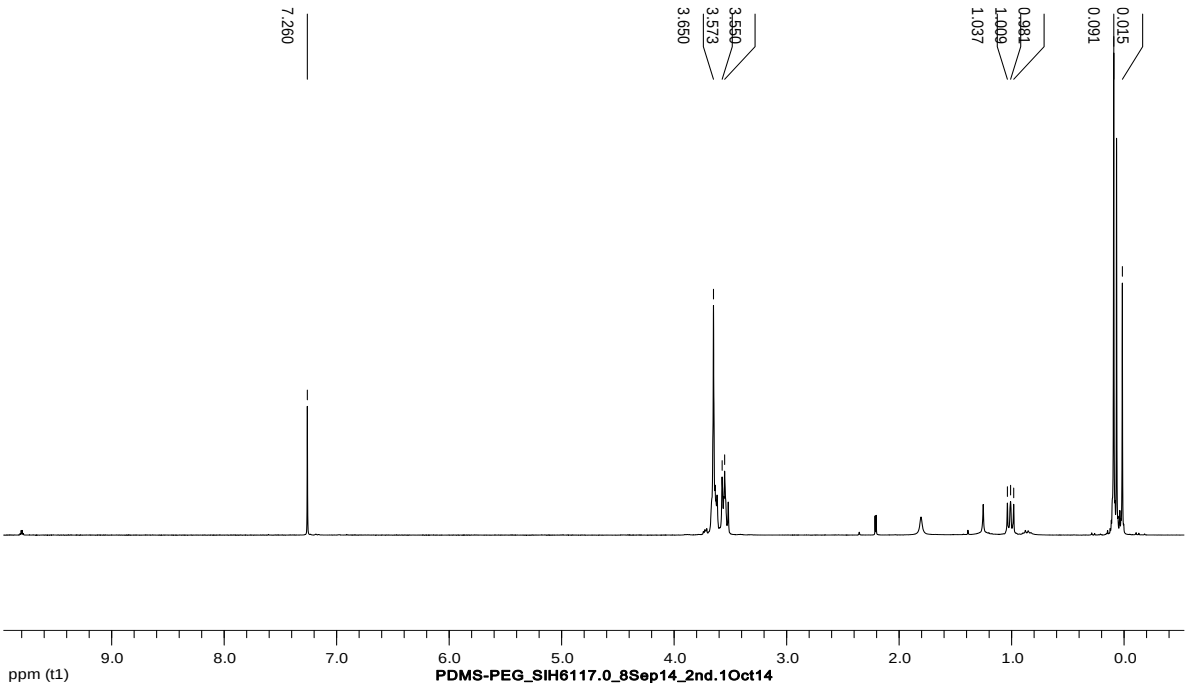

Fig. S1.d The NMR for PDMS3-PEG multiblock copolymer.

2. Data for binary blends (MJK/PDMS81)

The results of dielectric and mechanical properties are presented in figures (S2.a), (S2.b) & (S2.c) and (S2.d), respectively, for blends of MJK/PDMS81:

a. Dielectric permittivity of MJK/PDMS81

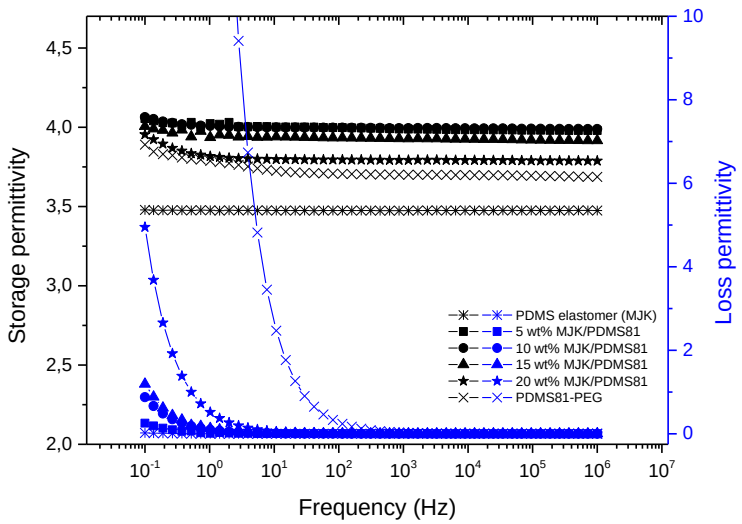

Fig. S2.a The relative storage and loss permittivity for MJK/PDMS81 (5 – 20 wt% of PDMS81-PEG) at 23 °C.

b. Conductivity of MJK/PDMS81

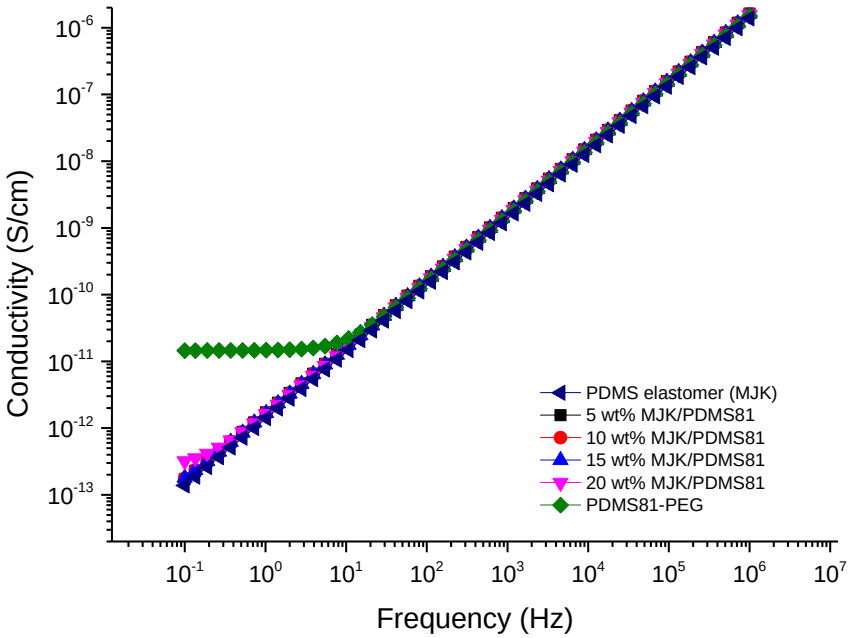

Fig. S2.b The conductivity of samples from MJK/PDMS81 (5 – 20 wt% of PDMS81-PEG) at 23 °C.

c. Dielectric loss factor of MJK/PDMS81

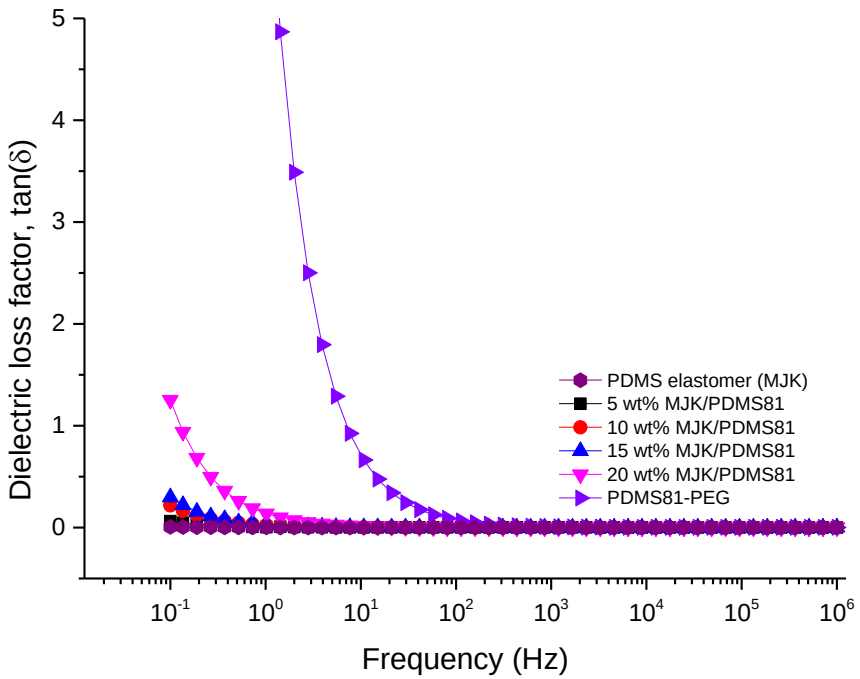

Fig. S2.c The dielectric loss factor for MJK/PDMS81 (5 – 20 wt% of PDMS81-PEG) at 23 °C.

d. Linear viscoelastic data of MJK/PDMS81

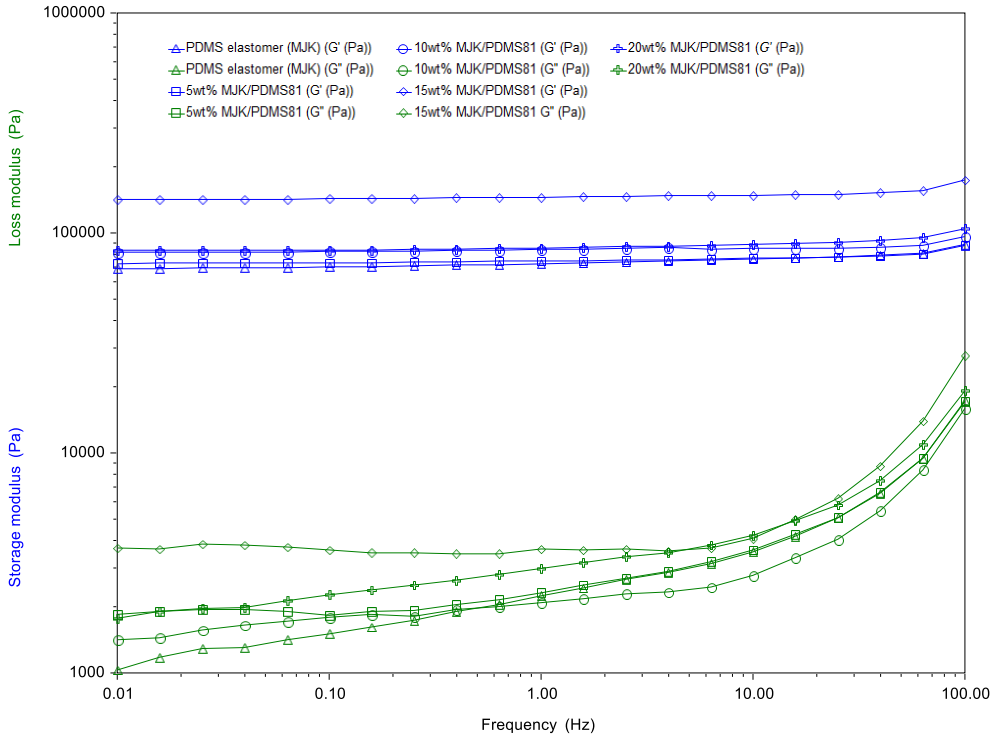

Fig. S2.d The storage and loss modulus for MJK/PDMS81 (5 – 20 wt% of PDMS81-PEG) at 23 °C.

3. Binary blends - MJK/PDMS14

The results of dielectric and mechanical properties are presented in figures (S3.a), (S3.b) & (S3.c) and (S3.d), respectively, for blends of MJK/PDMS14:

a. Dielectric permittivity of MJK/PDMS14

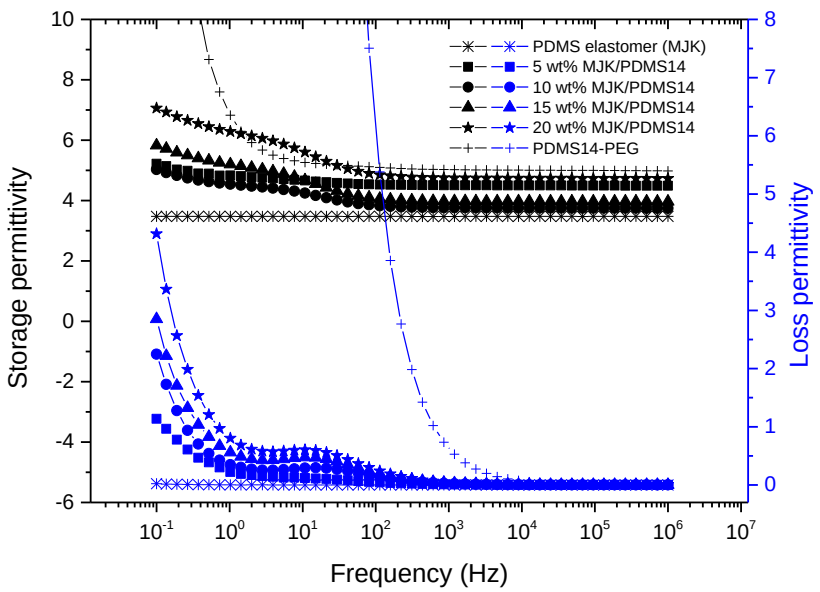

Fig. S3.a The relative storage and loss permittivity for MJK/PDMS14 (5 – 20 wt% of PDMS14-PEG) at 23 °C.

b. Conductivity of MJK/PDMS14

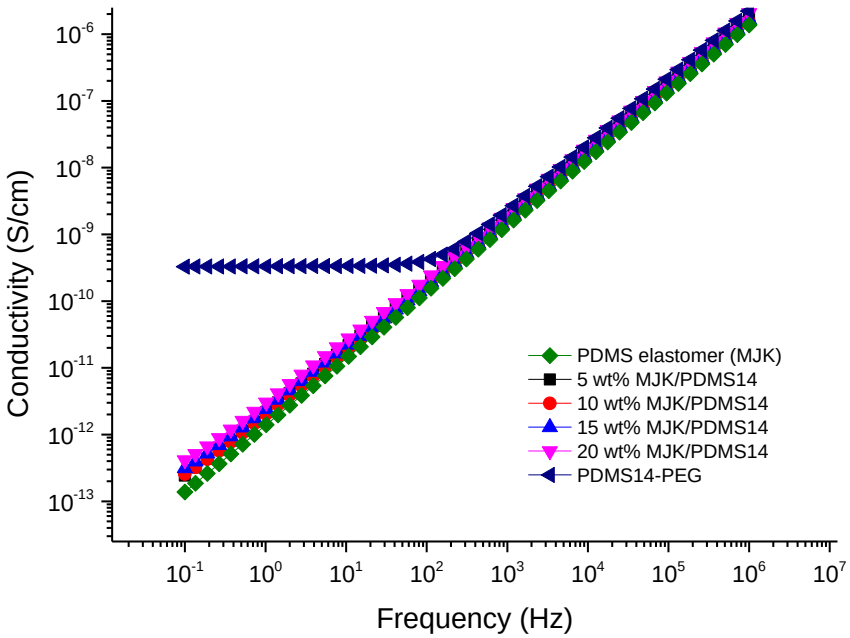

Fig. S3.b The conductivity for MJK/PDMS14 (5 – 20 wt% of PDMS14-PEG) at 23 °C.

c. Dielectric loss factor of MJK/PDMS14

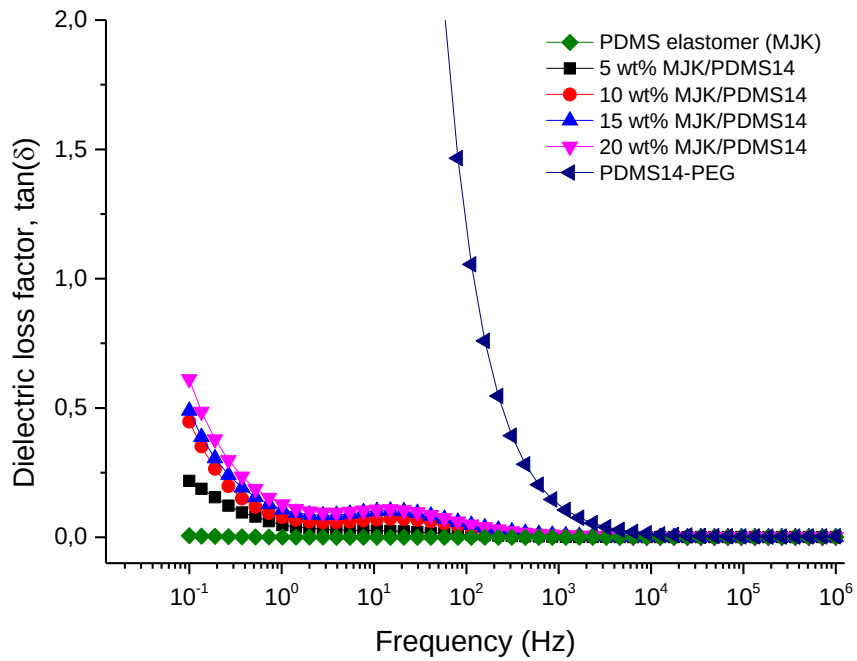

Fig. S3.c The dielectric loss factor for MJK/PDMS14 (5 – 20 wt% of PDMS14-PEG) at 23 °C.

d. Linear viscoelastic data of MJK/PDMS14

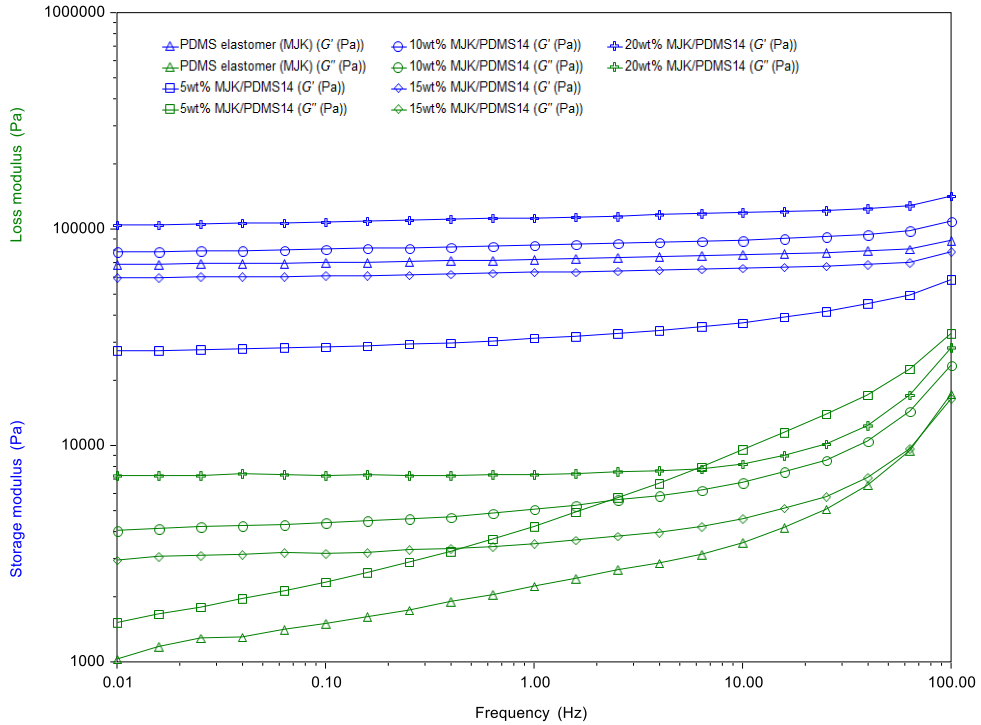

Fig. S3.d The storage and loss modulus for MJK/PDMS14 (5 – 20 wt% of PDMS14-PEG) at 23 °C.

4. Binary polymer blends - MJK/PDMS3

The dielectric and mechanical properties are presented in figures (S4.a), (S4.b) & (S4.c) and (S4.d), respectively, for blends of MJK/PDMS3:

a. Permittivity of MJK/PDMS3

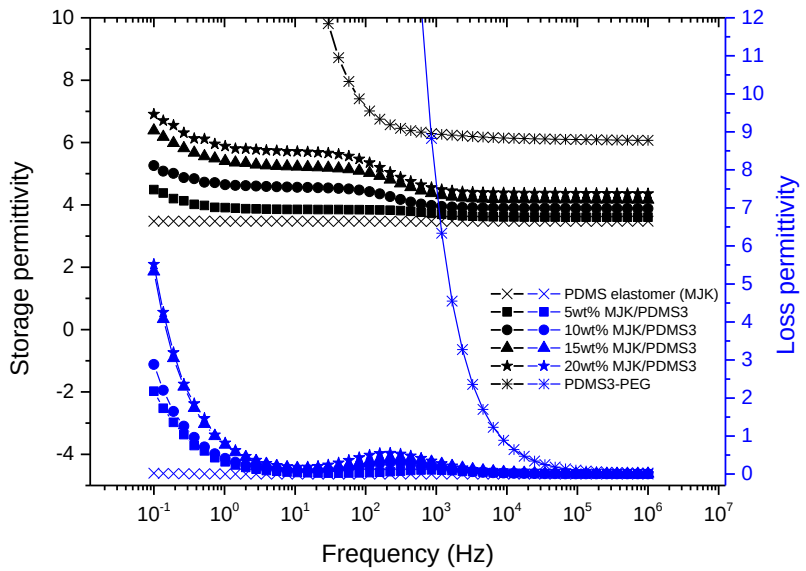

Fig. S4.a The relative storage and loss permittivity for MJK/PDMS3 (5 – 20 wt% of PDMS3-PEG) at 23 °C.

b. Conductivity of MJK/PDMS3

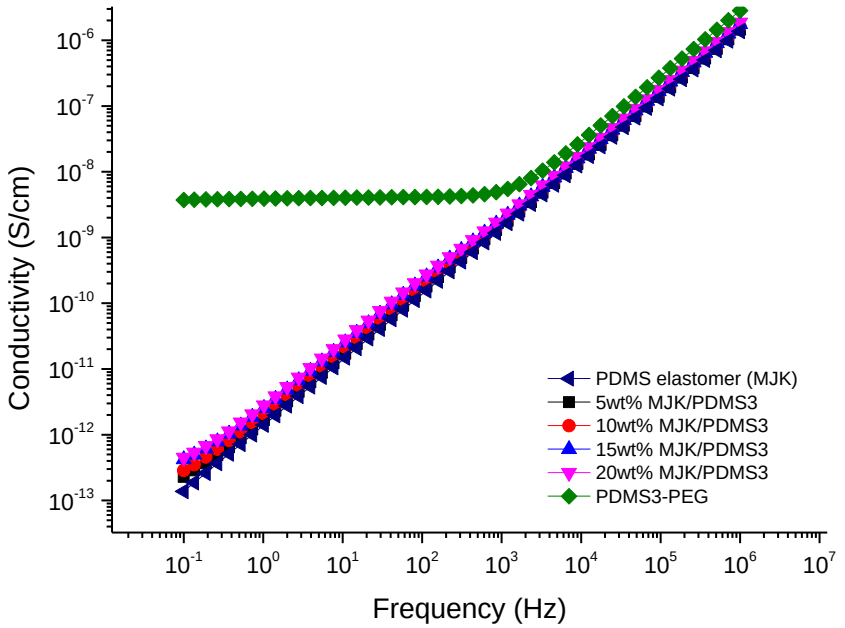

Fig. S4.b The conductivity for MJK/PDMS3 (5 – 20 wt% of PDMS3-PEG) at 23 °C.

c. Dielectric loss factor of MJK/PDMS3

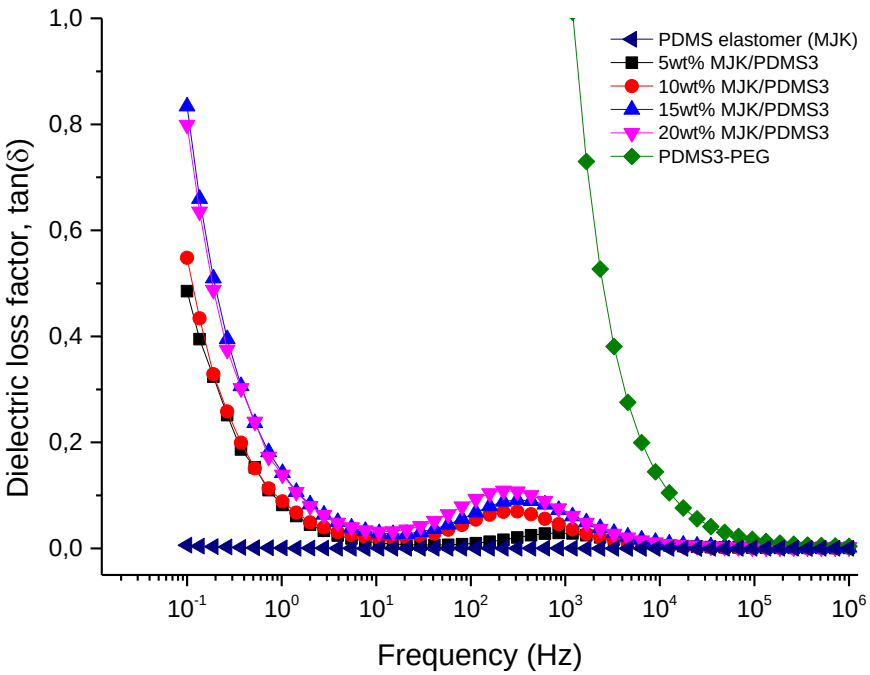

Fig. S4.c The dielectric loss factor for MJK/PDMS3 (5 – 20 wt% of PDMS3-PEG) at 23 °C.

d. Linear viscoelastic data of MJK/PDMS3

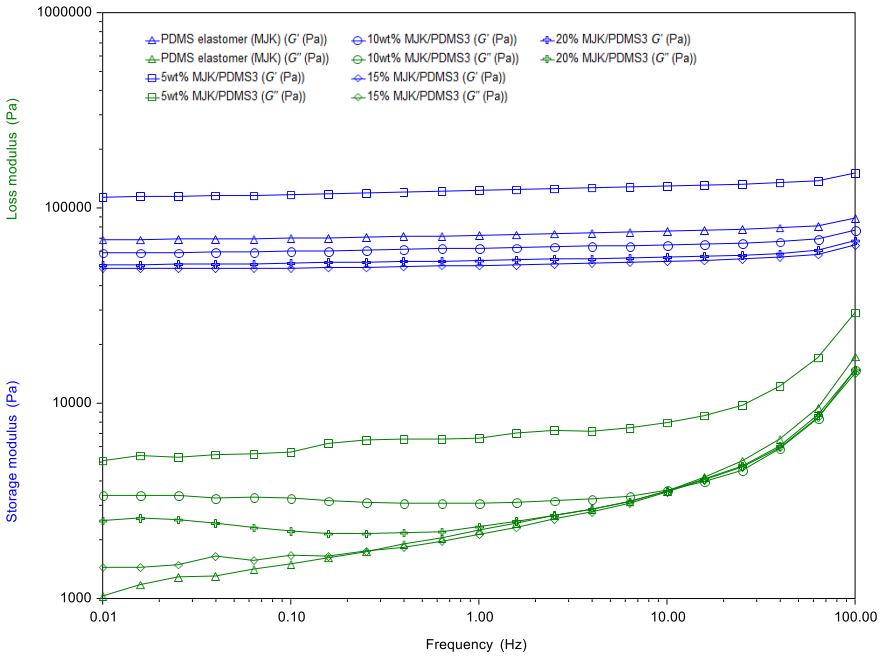

Fig. S4.d The storage and loss modulus for MJK/PDMS3 (5 – 20 wt% of PDMS3-PEG) at 23 °C.

5. Contact angles of PDMS-PEG multiblock copolymers

The coherence of hydrophobic behaviour between PDMS-PEG multi block copolymers and PDMS elastomer (MJK) with previously published data was investigated from the contact angle measurements. The block copolymer which comprises blocks of both hydrophobic PDMS and hydrophilic PEG, orients its polymer chains in such a fashion as to obtain the lowest possible surface energy.[1] The contact angle of MJK is coherent with the contact angle of e.g. another commercial PDMS (Sylgard 184)[1,2] and hence MJK act hydrophobically with a consistent contact angle of 105° throughout the period of measurement. On the other hand, the synthesized PDMS-PEG multiblock copolymers behave amphiphilic since the rearrangement of the polymer chains accounts for the change in contact angle over time. There is an obvious trend of decrement of contact angles from ~ 105° to below 95° with time for all the block copolymers and they behave similarly to previously published data[1,3]. The affinity towards hydrophobicity depends on the numbers of PEG in the PDMS-PEG block copolymer where greater numbers of PEG increase the tendency towards hydrophilic nature as expected. For instance, PDMS81-PEG is the most hydrophobic with a contact angle of 92° compared to the other block copolymers. The other multiblock copolymers have lower contact angle than PDMS81-PEG due to more PEGs in the block copolymers. PDMS3-PEG with 228 number of PEG chains possesses the lowest wettability (contact angle of nearly 65°).

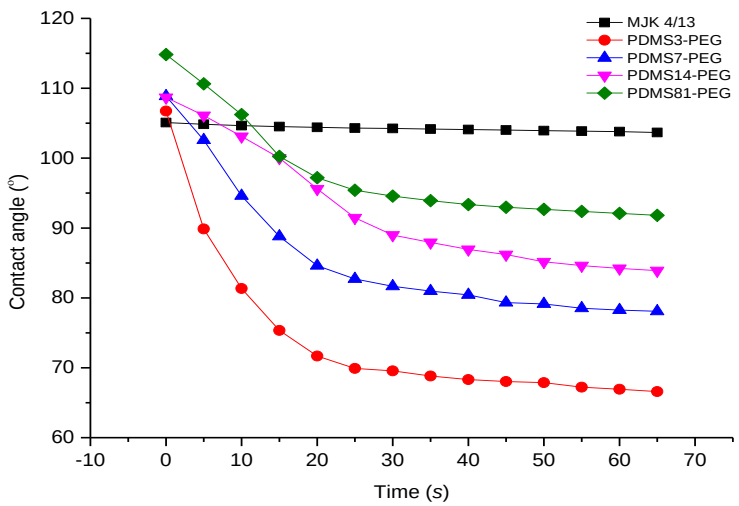

Fig. S5 The contact angles of PDMS-PEG multiblock copolymers and silicone elastomer (MJK 4/13) at 23 °C.

Reference

1. S. A. Klasner, E. C. Metto, G. T. Roman and C. T. Culbertson, *Langmuir*, 2009, **25**, 10390–10396.
2. J. A. Vickers, M. M. Caulum and C. S. Henry, *Anal. Chem.*, 2006, **78**, 7446–52.
3. H. Jukarainen, S. Clarson, J. Seppala and L. Oy, *Am. Chem. Soc.*, 2000, **729**, 353–357.

