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Green interpenetrated silicone-based elastomeric webs engineered as wave energy harvesters

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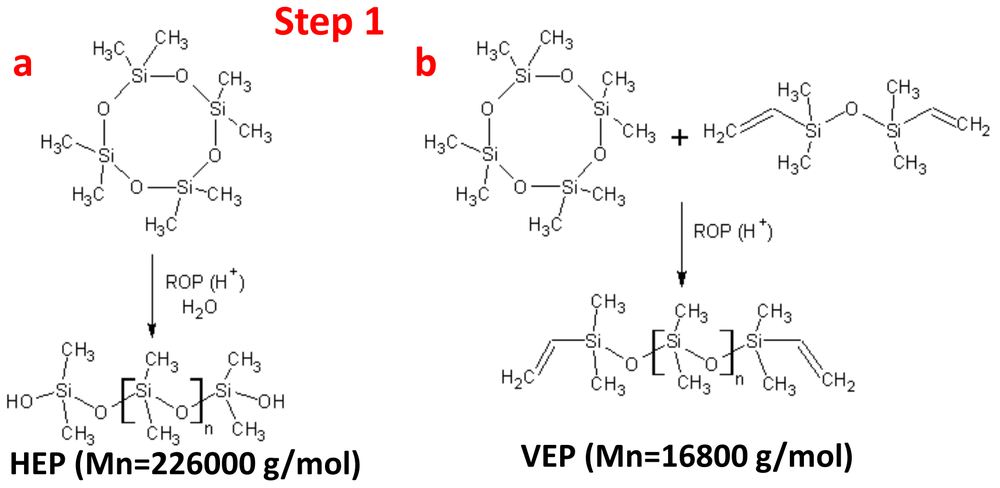
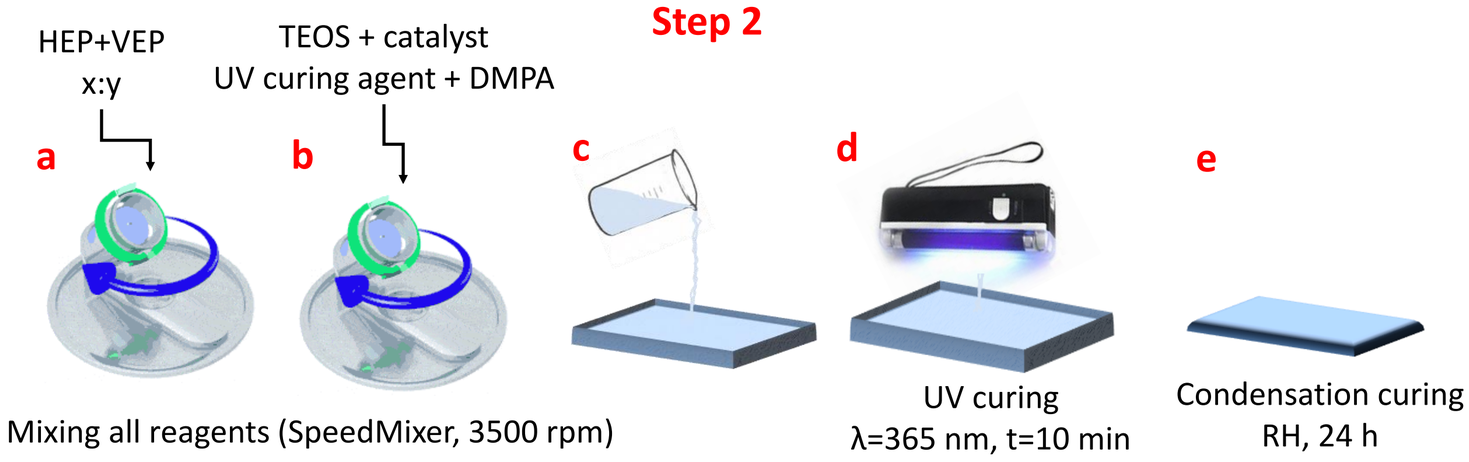
ABSTRACT

Wave Energy Harvesting using Dielectric Elastomers (DE) as power take-off (PTO) systems is a recently developed technology with great potential.[1-7] The Dielectric Elastomer PTO (DE-PTO) system is a "sandwich" consisting of a dielectric elastomer coated on both sides with compliant electrodes, thus forming a stretchable polymeric capacitor capable of converting mechanical energy into electric energy.[8] Recently, a DE-PTO system with two polymeric layers (approximately 20 cm in diameter) gave a remarkable average performance of 3.8 W/cycle.[3] The obtained results demonstrated the possibility of designing dielectric elastomer-based PTO systems that can be considered for large-scale electrical energy production. Silicone-based electromechanical transducers represent one of the most studied classes due to their great properties: high flexibility, low toxicity, resistance to weathering, good dielectric strength and operating on various temperatures (-120 to 200 ^{o}C). Besides these remarkable properties, they possess a relatively low elongation at break and a low dielectric permittivity. The main aim is to increase the conversion efficiency of silicone-based PTO systems by increasing the elongation at break and the dielectric permittivity of silicone elastomers in an original approach which consists in obtaining new silicone-based interpenetrated polymer networks (IPNs).

Step 1

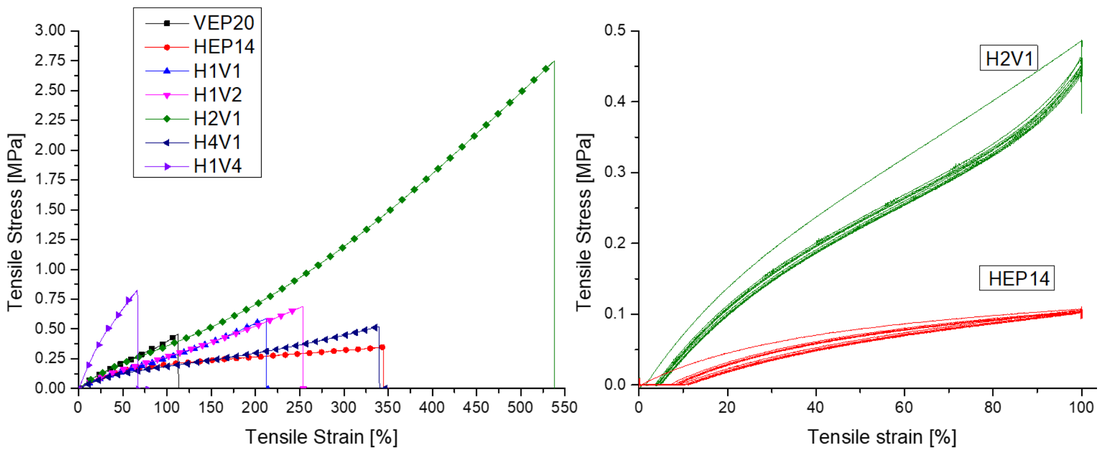


Step 2

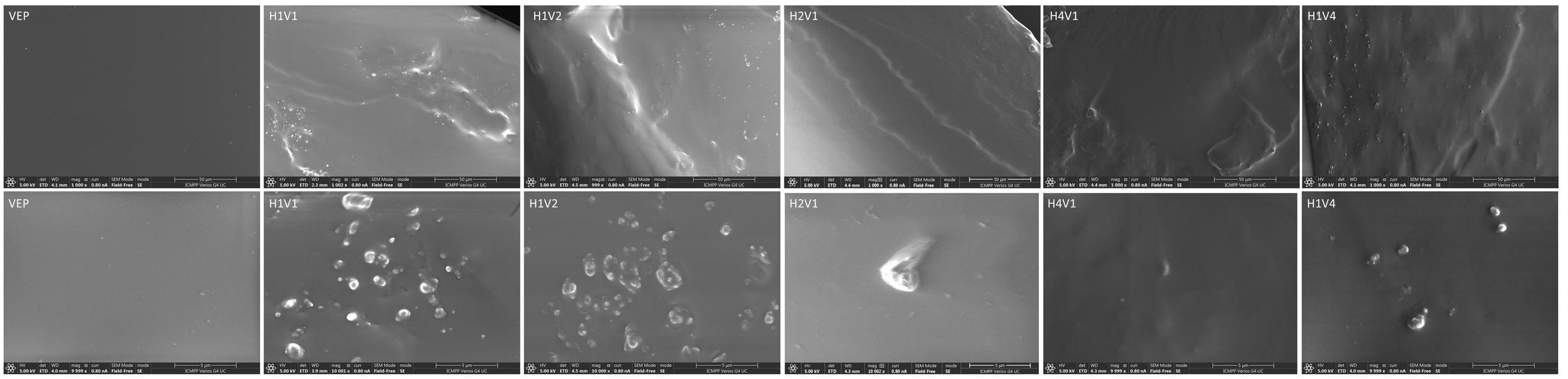


DE characterization

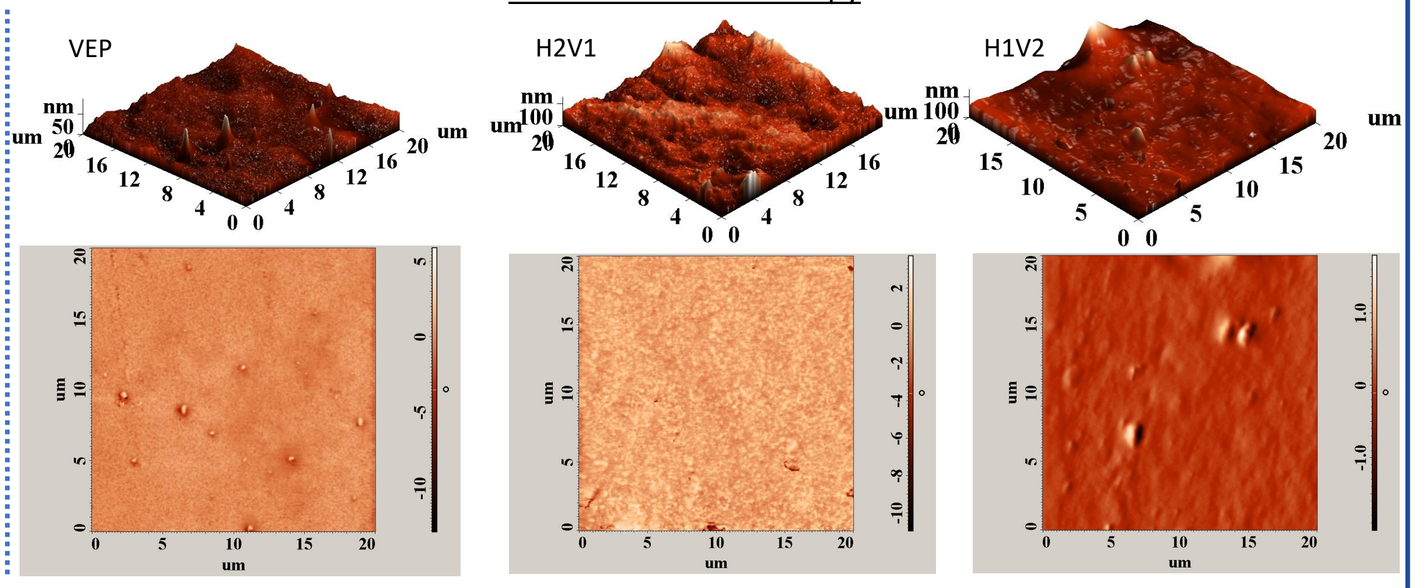
Mechanical characterization



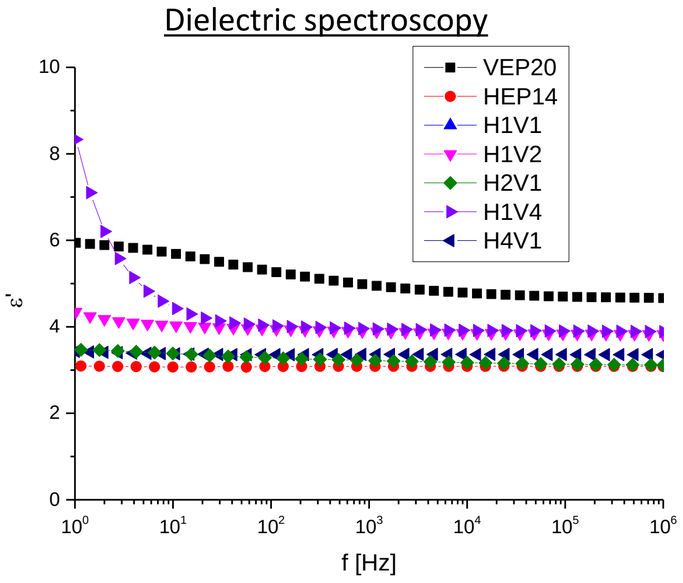
Scanning Electron Microscopy



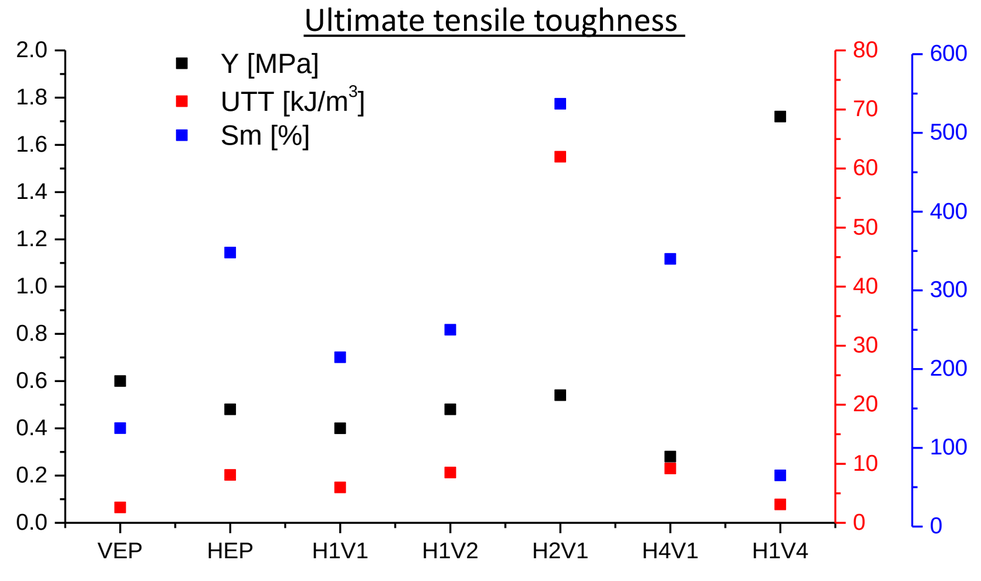
Atomic Force Microscopy



Dielectric spectroscopy



Ultimate tensile toughness



References

1-Thomson, G., Lai, Z., Val, D. V., Yurchenko, D., J. Sound Vib., 442, 167–182, 2019; **2**-P Mazurek, S Vudayagiri, AL Skov ,Chem Soc Rev, 48, 1448-1464, 2019; **3**-Moretti, G., Papini, G. P. R., Daniele, L., Forehand, D., Ingram, D., Vertechy, R., Fontana, M., Proc. R. Soc. A Math. Phys. Eng. Sci., 475, 20180566, 2019; **4**-Moretti, G., Papini, G. P. R., Righi, M., Forehand, D., Ingram, D., Vertechy, R., Fontana, M., Smart Mater. Struct., 3, 27, 2018; **5**-Fan, P., Chen, H., Polymers, 12, 10, 2018; **6**-Ikegame, T., Takagi, K., Ito, T., Kojima, H., Yoshikawa, H., Electroact. Polym. Actuators Devices, 10163, 1016331, 2017. **7**-Cao, J. B., Shi-Ju, E., Guo, Z., Gao, Z., Luo, H. P., AIP Adv., 11, 7, 2017; **8**-Pelrine, R., Kornbluh, R. Proc. of SPIE., 4329, 148–156, 2001.

Conclusions

- The properties of the resulted IPNs are drastically influenced by the x:y ratio;
- The rigid network (VEP) form agglomerates, acting as a reinforcing agent; thus, the ratio 2:1 led to an elastomer with superior mechanical properties (>500 % elongation, low increased tensile stress and low visco-elastic losses) without phase separation
- The dielectric permittivity values are low, due to the non-polar nature of siloxanes. Future work focuses on attaching polar groups to the HEP polymer
- The ultimate tensile toughness (UTT) is drastically influenced by the mechanical properties, thus the ratio 2:1 gave the highest value.

Acknowledgements

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