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Silicone elastomers with high-permittivity ionic liquids loading

Xue Liu (1)(2), Yi Nie (2), Liyun Yu (1), Suojiang Zhang (2), Anne Ladegaard Skov(1)*

(1) Danish Polymer Centre, Department of Chemical and Biochemical Engineering, Technical University of Denmark, Kgs. Lyngby, Denmark;
(2) CAS Key Laboratory of Green Process and Engineering, Institute of Process Engineering, Chinese Academy of Sciences, Beijing, China;

Abstract
Dielectric elastomers transducers (DETs) represent a promising transducer technology, due to their excellent ability to undergo large and reversible deformations under an applied electric field. The most obvious challenge facing current DETs is the high driving voltages necessary to drive them, and so an effective way to overcome this shortcoming is to increase the dielectric permittivity of the applied elastomers. Ionic liquids (ILs), which have gained significant attention in recent years, have high permittivity but also high conductivity. It is therefore interesting to blend ILs into elastomers to increase their dielectric permittivity while focusing on maintaining the non-conductive nature of the elastomers. Herein, high-permittivity silicone elastomers were prepared from blending in ILs. The influence of the structure and the content of ILs on the material properties was discussed, and important properties for material applications as DETs, such as dielectric permittivity, gel fraction and mechanical properties, were also investigated. It was found that 1-butyl-3-methylimidazolium hexafluorophosphate (BmimSbF6) is the most suitable IL for the given elastomer system. The dielectric permittivity of the elastomers increased with the increasing content of BmimSbF6. The Young’s modulus decreased in line with the increasing content of BmimSbF6 as expected. A simple figure of merit ($F_\text{om}$) for actuators was used and the resulting $F_\text{om}$ of elastomer with 50 phr IL loading is 10.40 thereby indicating that the material has a great advantage when used in actuators.

Background

- **Properties of PDMS**
  - Transparent
  - Flexible
  - High mechanical and chemical stability

- **Introduction of ionic liquids (ILs)**
  - High chemical stability and thermal stability
  - Liquid at room temperature
  - Low vapor pressure
  - High dielectric permittivity
  - Tunable structure and properties
  - Wide electrochemical window
  - High electrical conductivity

**Properties of ILs**
- Low dielectric permittivity
- High permittivity
- Low conductivity

Results and discussion

- **Effect of BmimSbF6 content on dielectric properties**
- **Effect of BmimSbF6 content on mechanical properties**
- **Effect of BmimSbF6 content on $F_\text{om}$**

Conclusion

- Very few ILs are compatible with Pt curing chemistries; BmimSbF6 is one of those.
- The storage permittivity of film increased in line with increasing BmimSbF6 content.
- The elastomers with IL loaded became increasingly softer in line with an increasing content of BmimSbF6.
- The figure of merit ($F_\text{om}$) increased with increasing BmimSbF6 content.

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