Accepted Manuscript

Title: Dielectric phenomena and electrical energy storage of poly(vinylidene fluoride) based high-k polymers

Authors: Yingke Zhu, Pingkai Jiang, Zhicheng Zhang, Xingyi Huang

PII: S1001-8417(17)30337-6
DOI: http://dx.doi.org/10.1016/j.cclet.2017.08.053
Reference: CCLET 4202

To appear in: *Chinese Chemical Letters*

Received date: 4-5-2017
Revised date: 23-8-2017
Accepted date: 30-8-2017

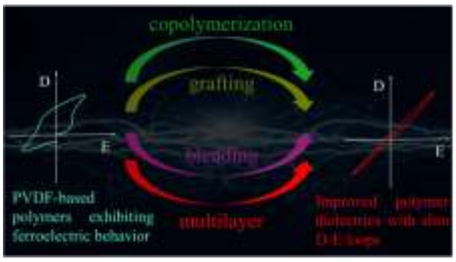
Review

Dielectric phenomena and electrical energy storage of poly(vinylidene fluoride) based high-k polymers

Yingke Zhu[a], Pingkai Jiang[a], Zhicheng Zhang[b,*], Xingyi Huang[a,*]

[a] *Department of Polymer Science and Engineering, Shanghai Key Laboratory of Electrical Insulation and Thermal Aging, Shanghai Jiao Tong University, Shanghai 200240, China*
[b] *Department of Applied Chemistry, School of Science, Xi'an Jiaotong University, Xi'an 710049, China*

Graphical abstract



Since the discovery of relaxor ferroelectric behavior was firstly reported in irradiated poly(vinylidene fluoride-trifluoroethylene) (P(VDF-TrFE)) copolymer, many strategies have been developed to enhance the electrical energy storage capability, including copolymerization, grafting, blending and fabricating of multilayer. This review article mainly summarizes the recent progresses on these strategies and aims to motivate the development of novel PVDF-based polymers for electrical energy storage and dielectric applications.

ABSTRACT
Polymeric dielectrics have wide range of applications in the field of electrical energy storage because of their light weight and easy processing. However, the state-of-the-art polymer dielectrics, such as biaxially orientated polypropylene, could not meet the demand of minimization of electronic devices because of its low energy density. Recently, poly(vinylidene fluoride) (PVDF) based ferroelectric polymers have attracted considerable interests for energy storage applications because of their high permittivity and high breakdown strength. Unfortunately, the high dielectric loss and/or high remnant polarization of PVDF-based polymers seriously limits their practical applications for electrical energy storage. Since the discovery of relaxor ferroelectric behavior was firstly reported in irradiated poly(vinylidene fluoride-trifluoroethylene) (P(VDF-TrFE)) copolymer, many strategies have been developed to enhanced the electrical energy storage capability, including copolymerization, grafting, blending and fabricating of multilayer. How these methods affect the polymorphs, crystallinity, crystal size of PVDF-based polymers and the connection between these microstructures and their corresponding energy storage properties are discussed in detail.

Keywords:
PVDF
Ferroelectric polymer
Copolymerization
Grafting
Energy storage
Dielectric constant
Dielectric loss
Breakdown strength

1. Introduction

As energy issue is increasingly severe, lots of work has been conducted to explore energy storage devices, such as batteries [1-3], fuel cells [4-7], capacitors [8-11], and supercapacitors [12-14]. Owing to its fast charge and discharge speed, dielectric capacitors possess the highest power energy density but are seriously limited by their low energy density for energy storage applications. As the mostly commercialized polymers for capacitors, biaxially oriented polypropylene (BOPP), possesses a high dielectric strength (> 700 MV/m), and low dielectric loss (tan δ ~ 0.0002 at 1 kHz). However, its energy density is rather low owing to its low dielectric constant (2.2 at 1 kHz) induced by the nonpolar polymer skeleton [8,15,16]. With the increasing demand of miniaturization and integration of electronic devices, dielectric materials with high energy density and low dielectric loss are highly desired and the major challenge for the scientists.

Generally, energy density (U_e) of dielectric materials could be calculated from equation $U_e = \int E dD$ [17], where E is the applied electrical field, and D is electrical displacement. With regard to linear dielectric materials (*D-E* loops can be seen in curve 2 in Fig. 1), such as BOPP, U_e could be derived from the following equation [18].

Corresponding authors.
E-mail addresses: xyhuang@sjtu.edu.cn (X. Huang), zhichengzhang@mail.xjtu.edu.cn (Z. Zhang)