Design and Preparation of Bio-based Dielectric Elastomer with Polar and Plasticized Side Chains

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Table S1. Glass transition temperature (T_g) of poly (di-*n*-alkyl itaconates) (PDAI) [1, 2]

PDAI	T_g/℃
Dimethyl (PDMI)	95
Diethyl (PDEI)	58
Di-*n*-propyl (PDPrI)	34
Di-*n*-butyl (PDBI)	12
Di-*n*-pentyl (PDPeI)	5
Di-*n*-hexyl (PDHxI)	-18
Di-*n*-heptyl (PDHpI)	-23
Di-*n*-octyl (PDOI)	-20
Di-*n*-nonyl (PDNI)	-11
Di-*n*-decyl (PDDI)	-3

In Table S1, the T_g of PDAI decrease first as the side chains increase in length from methyl to heptyl. PDAI bearing the flexible pendant groups are similar to the small-molecular additives by pushing the chains further apart and thereby producing a change in T_g. The T_g increasing is observed from heptyl to decyl for the developing order tendency of the long side chains. Considering the polarity of di-*n*-alky itaconates also, di-*n*-butyl itaconate was used to synthesize the dielectric elastomer. Furthermore, bio butanol is a promising biofuel product in the word.

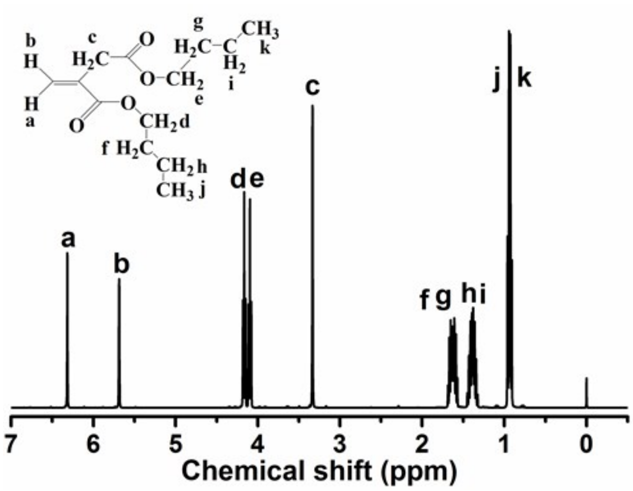
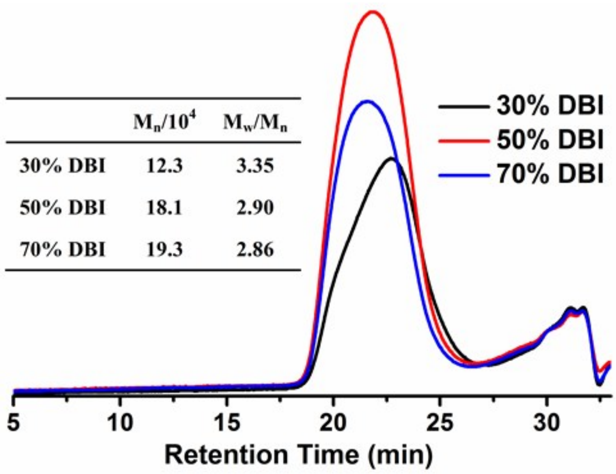


Figure S1. [1]H NMR spectrum of di-*n*-butyl itaconate (DBI)



	$M_n/10^4$	M_w/M_n
30% DBI	12.3	3.35
50% DBI	18.1	2.90
70% DBI	19.3	2.86

Figure S2. GPC traces for PDBII with different itaconate to isoprene feed ratios. (DBI: di-*n*-butyl itaconate, i.e., 30% DBI means 30 wt % DBI in the feed. In inserted table, M_n : number-average molecular weight, M_w/M_n: polydispersity ratio (weight average molecular weight/number-average molecular weight), by GPC (polystyrene calibration))

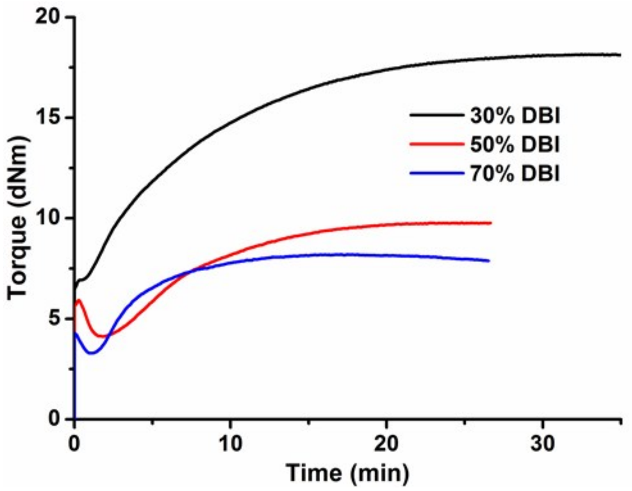


Figure S3. The curing curves of PDBII with different content of DBI in the feed. (70% DBI stands for 70% DBI in the feed.)

Table S2. The optimum cure time of PDBII with different content of DBI in the feed. (70% DBI stands for 70% DBI in the feed.)

Formulations	T90 (min:s)
70% DBI	9:36
50% DBI	14:52
30% DBI	17:39

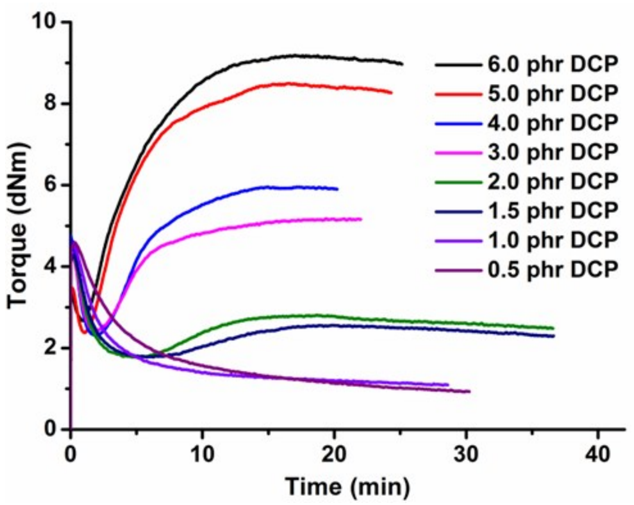


Figure S4. The curing curves of PDBII with 70% di-*n*-butyl itaconate in the feed crosslinked by different content of DCP.

Table S3. The optimum cure time of PDBII with 70% di-*n*-butyl itaconate in the feed crosslinked by different content of DCP.

Formulations	T90 (min:s)
0.5 phr DCP	-
1.0 phr DCP	-
1.5 phr DCP	16:14
2.0 phr DCP	13:25
3.0 phr DCP	11:11
4.0 phr DCP	10:33
5.0 phr DCP	9:58
6.0 phr DCP	9:56

Table S4. Curing characteristics and elastic modulus of $BaTiO_3$ filled PDBII with 70% di-n-butyl itaconate in the feed.

Items	$BaTiO_3$/phr					
	0	10	30	50	70	90
S_{max}(dNm)	8.50	8.05	8.60	10.81	11.27	9.82
S_{min}(dNm)	2.38	1.51	1.57	1.67	1.72	1.72
ΔS(dNm)	6.12	6.54	7.03	9.14	9.55	8.10
Elastic modulus/MPa	0.420	0.146	0.180	0.214	0.290	0.158
T90 (min:s)	8:49	12:32	12:30	10:41	10:21	11:47

Table S5. Comparing actuation strain of PDBII elastomer with other dielectric elastomers.

Material	Prestrain (x,y) (%)	Area strain[a] (%)	Field Strength[a] (kV/mm)	Ref.
PANI-g-PolyCuPc-g-PU	0, 0	7	23	3
23 wt %PANI/P(VDF-TrFE-CTFE)	0, 0	1.5	9.5	4
PANI@PDVB/PDMS	0, 0	12	54	5
14PANI/15PolyCuPc/85PU	0, 0	9.3	20	3
SEBS-MA grafted PANI	0, 0	1.4	27	6
NBR/TiO_2/DOP	0, 0	3.04	20	6
5 wt % CNTs/PDMS	0, 0	4.4	1.5	7
P(VDF-TrFE)/40 wt %CuPc	0, 0	1.91	13	8
Polyester elastomer	0, 0	11.9	15.6	9
PDBII	0,0	14	20	
	0,0	20	30	
	0,0	25	40	

a. Estimated from graphical data in cited reference

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